MINERAL REPORT 30

CANADIAN MINERALS YEARBOOK 1980

Energy, Mines and Resources Canada
Minerals

Énergie, Mines et Ressources Canada
Minéraux

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Foreword

This issue of the Canadian Minerals Yearbook is a comprehensive report of developments in the mineral industry during 1980. In order to provide information as early as possible to all interested persons, the 49 chapters dealing with individual commodities and all other chapters were issued previously as Annual Mineral Reviews, 1980. The General Review deals with the main events and trends in the Canadian economy during the year, as well as overall developments in the mineral industry. The Company index lists the accurate full names of all companies mentioned in the text and the page number of each mention, thus providing a complete cross-reference to the activities of companies engaged in the Canadian mineral industry. The text is also supported by pocket map 900A, Principal Mineral Areas of Canada.

The Canadian Minerals Yearbook has been published under that title, or other titles, since 1886 and is the permanent official record of the mineral industry in Canada. Those wishing to refer to previous Yearbooks or reports should consult departmental catalogues, available in most libraries.

The basic statistics on Canadian production, trade and consumption were collected by the Information Systems Division, Mineral Policy Sector, Energy, Mines and Resources Canada, and by Statistics Canada, unless otherwise stated. Company data were obtained by the authors directly from company officials through surveys or correspondence, or from corporate annual reports. Market quotations are mainly from standard marketing reports.

Energy, Mines and Resources Canada is grateful to all those who contributed information necessary to compile this report.

December 30, 1982

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Readers wishing more recent information than that contained in this volume should obtain the 1981 series of mineral reviews: a complete set costs $48 in Canada and $57.60 in other countries, while individual copies sell for $1.00 in Canada and $1.20 in other countries. They may be ordered from Canadian Government Publishing Centre, Supply and Services Canada, Hull, Quebec, Canada, K1A 0S9. Prices subject to change without notice.

Front Cover:
Shrouded in early-morning mist, a wagon drill carries out exploratory drilling on property of United Keno Hill Mines Limited, an important lead-silver producer in the Mayo area of the Yukon. (George Hunter photo)

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503 Titanium and Titanium Dioxide
509 Tungsten
517 Uranium
537 Zinc
555 Zirconium
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Mineral Map 900A, Principal Mineral Areas of Canada in pocket on inside back cover

Conversion Factors

Imperial units to Metric (SI) Units

Ounces to grams	x	28.349 523
Troy ounces to grams	x	31.103 476 8
to kilograms	x	.031 103 476
Pounds to kilograms	x	.453 592 37
Short tons to tonnes	x	.907 184 74
Gallons to litres	x	4.546 09
Barrels to cubic metres	x	.158 987 220
Cubic feet to cubic metres	x	.028 346 85

Source: Canadian Metric Practice Guide

General Review

INFORMATION SYSTEMS DIVISION

The state of the Canadian economy in 1980 was reflected in the fact that the Gross National Product (GNP), a measure of overall economic activity, remained virtually unchanged in real terms with an increase of 0.12 per cent over 1979. This was the smallest increase in GNP since the mid-1950s. The economic well-being of the nation, as measured by real GNP per capita, fell by 1.1 per cent from $547,000 in 1979 to $541,000 in 1980. The consumer price index, a measure of inflation, rose by 10.1 per cent, but the rate of increase was less than that of other major industrialized nations except for Japan (8 per cent) and West Germany (5.4 per cent). The unemployment rate remained steady at 7.5 per cent for the second year in a row, although Canada's labour force increased by 1.0 per cent. The high levels of inflation and unemployment, fed by high energy costs, record high interest rates and low productivity levels contributed to a disappointing year.

Total investment in plant and equipment which had increased 9 per cent in 1979, rose by only 6 per cent in 1980 (in real terms). Total volume of exports was down almost 5.0 per cent due mainly to the recession in the United States, but high export prices and a decline in imports of approximately 2 per cent resulted in a trade surplus of about $7.9 billion for the year. When combined with a deficit of $10.7 billion in the service sector, the total deficit in 1980 approached $3.0 billion. Recession, deeply seated by mid-year in the United States filtered into Canada by early fall, further weakening the economy.

Demand, sluggish throughout the year dropped sharply by the fourth quarter affecting all sectors of the economy. Some sectors were hit harder than others. Manufacturing showed a negative growth rate of about 2.5 per cent and forestry showed little or no growth over the period. Agricultural production declined approximately 5 per cent, causing farm net incomes to drop considerably. The overall index of Real Domestic Product (RDP) 1971=100 was up slightly by 0.2 per cent. The mining industry as a whole was the exception in 1980 registering an RDP increase of 1.7 per cent, with increases of 5.1 per cent in metal mining and 2.5 per cent in nonmetal mining (coal excluded). A decrease of 2.6 per cent took place in the mineral fuel sector. The RDP index for mining stood at 118.3, approaching the high of 119.3 attained in 1973. In mineral manufacturing, the RDP index for nonmetallic mineral product manufacturing decreased from 122.4 to 112.9 and that of petroleum and coal products from 142.7 to 141.9. The same index for primary metals manufacturing rose from 123.9 to 127.7.

PRODUCTION

In 1980, total value of mineral production reached $32 billion, 11.4 per cent of GNP; up from 10.0 per cent in 1979. The value of nonfuel mineral industry output increased 21.2 per cent over the previous year with the nonmetallic sector showing the greatest change. Value of fuel production including coal, natural gas and petroleum increased 26.4 per cent from $14.6 billion in 1979 to $18.5 billion in 1980. On a commodity basis, gold and silver changed most significantly. For both precious metals, volume of output declined but value of output showed increases of 72.7 per cent and 71.0 per cent respectively. Nickel showed a 54.1 per cent increase in volume and a 102.6 per cent increase in value. Of the major nonmetals and structural materials, only clay products showed a decline in value (5.9 per cent).

Generally, changes in value were not as significant as in the previous year, as reflected in the industry selling price indexes. The indexes (based on 1971=100), particularly in the ferrous and nonferrous metals sector, were up in 1980 over 1979, but by a much lower rate than that experienced in the previous year. The index for metal rolling, casting and extruding increased 29.4 per cent in 1979 over that of 1978, but only 5.6 per cent in 1980, revealing an overall downward trend in prices by the end of the year.

Copper, a key industrial metal and considered a benchmark for prices in nonferrous metal markets, showed a price range at the end of the year of 96 cents to $1.10 per pound. The wide fluctuation and record high of $US 1.43 a pound experienced in 1979 and early 1980 were not carried over into the last half of 1980. Labour disputes in the U.S. copper industry caused extended shutdowns of much of that country's production facilities, but still, inventories were increasing. Demand for copper products including wire, cable and brass mill products was strongly affected by the severe slowdowns in the housing and automotive industries.

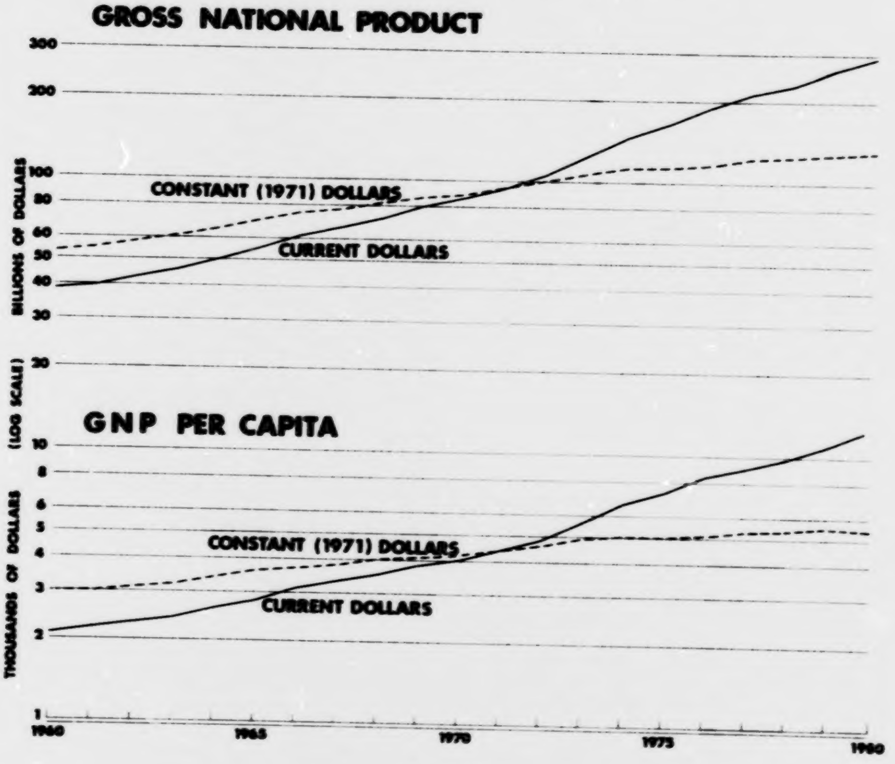


Figure 1

CANADA
POPULATION AND LABOUR FORCE

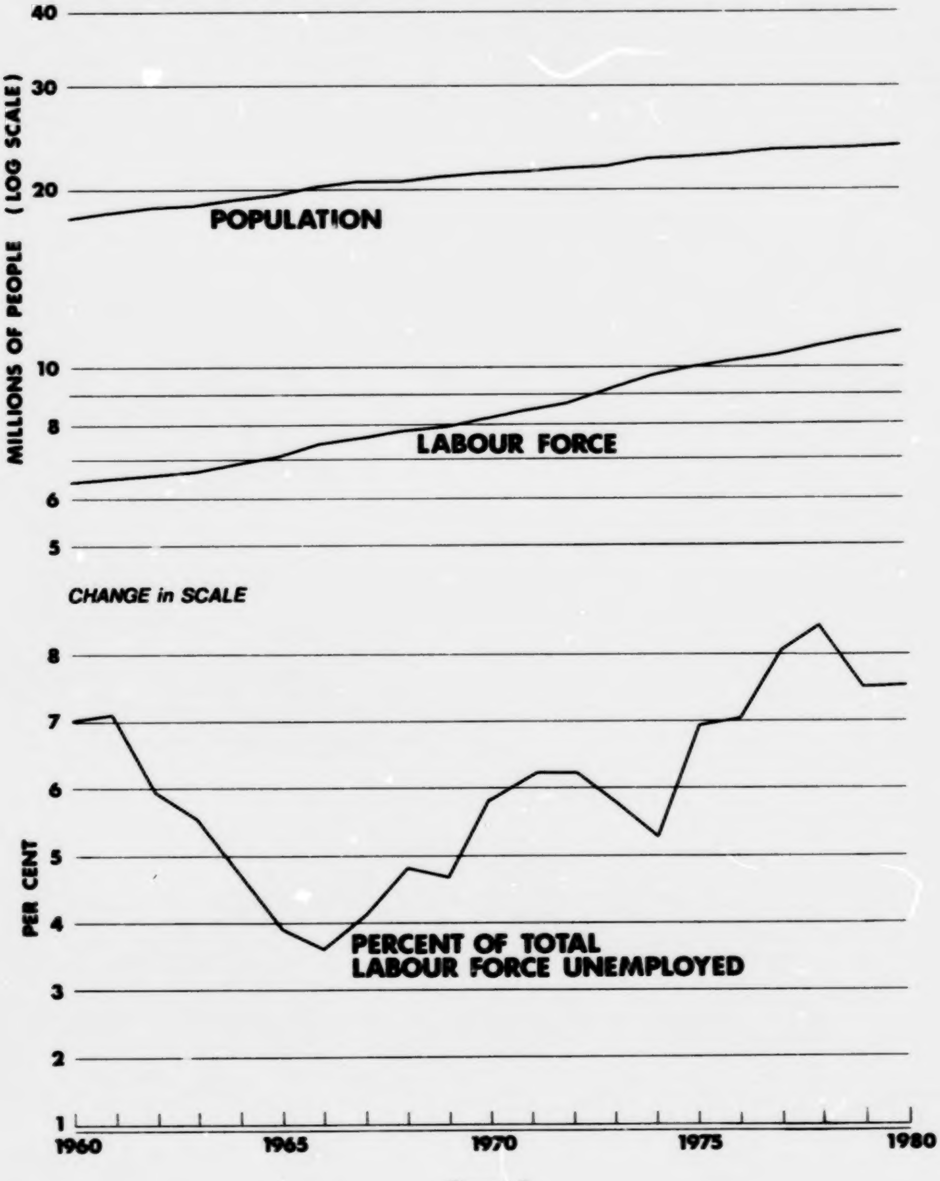


Figure 2

Similar conditions existed in molybdenum markets. Produced mainly as a byproduct of copper mining, it is used primarily as an additive in special steels such as stainless steel and machine tool steel. Depressed markets and declining prices caused by recession in the United States and Canada were further aggravated by increases in the supply of the metal from new sources. The reverse was true in earlier years, when, supplies were tight and prices strong, these factors led to exploration and a surge in new developments. New developments to come on-stream in the next year will cause a position of world oversupply and keep prices depressed, at least until the economic picture starts to improve.

Markets for precious metals cooled considerably during 1980. Price strength in gold, though still apparent, was not as dramatic as in the previous year. Reaction to record high interest rates caused prices to drop in the latter part of the year, hitting $US 558 an ounce on December 11 on the London market. Some concern was expressed when the U.S.S.R. began to sell on the open market, reportedly to purchase grain after a devastating harvest. However, the volume of sales was conservative and did not cause any real downward pressure on price. To help spur demand, the South African government introduced smaller coins than the one ounce Krugerrand, thereby making gold more obtainable to the general public. However, sales of the larger coins peaked near year-end while sales of the mini-coins were disappointing, perhaps due to higher premiums on the latter.

Silver, after following the price lead of gold and reaching heights of $US 40-50 an ounce in the first quarter of 1980, plunged deeply in April. By year-end, it was trading at a level of $US 15-18 an ounce. Other precious metals including platinum, palladium and rhodium all experienced falling prices as the year drew to a close.

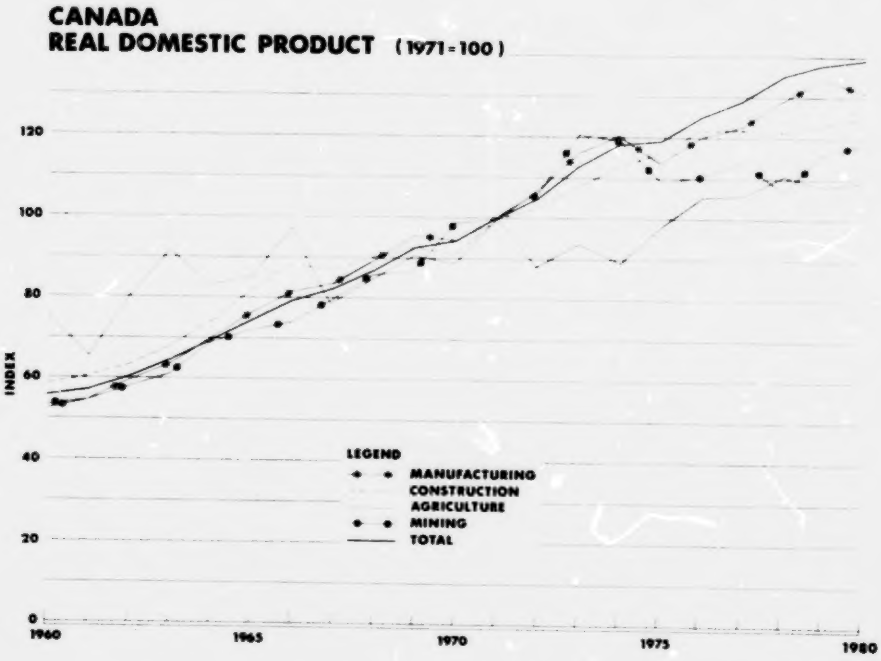


Figure 3

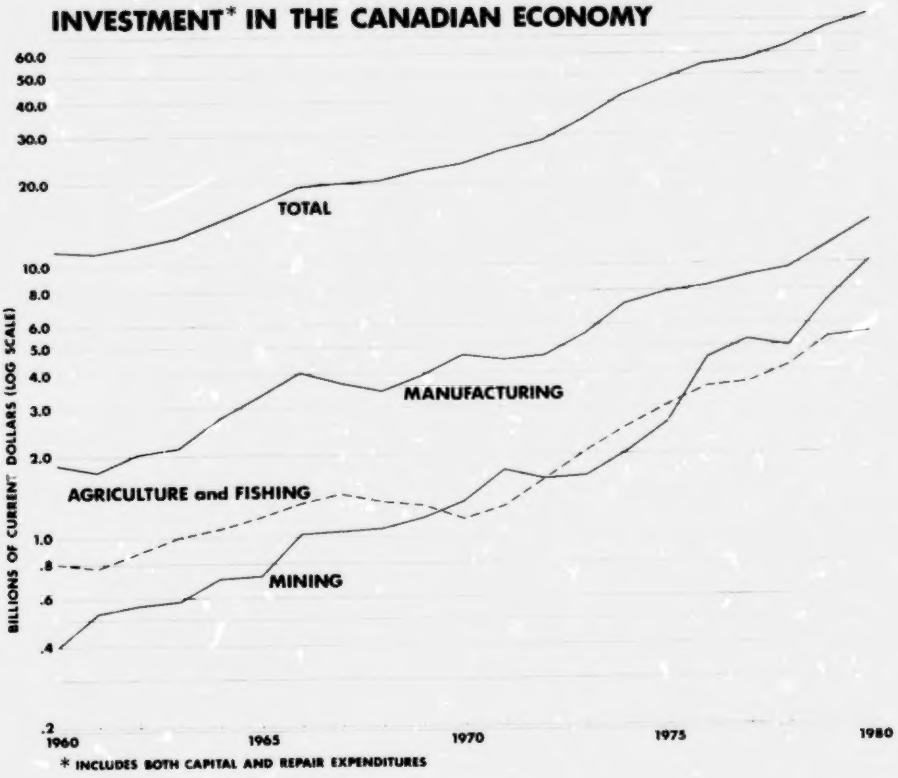


Figure 4

Output of nickel reached 194 900 t in 1980, up from 126 500 t in 1979. The 54 per cent increase was an encouraging recovery from the cutbacks experienced in 1978 and 1979 but was still far below levels achieved in 1976 and 1977. Production at that time was 240 825 t and 235 212 t respectively. Producers, perhaps to avoid a recurring situation of oversupply and high inventories, were cutting back production by the end of the year.

The lead market faced a year of weak demand although there was some improvement in the fall as battery sales rose. Despite a cutback in production of almost 12 per cent, inventories had started to build. A similar situation existed with zinc. A strike at Brunswick Mining and Smelting Corporation Limited that began in late May and not settled until the end of September kept production down but demand fell about 8 per cent at the same time, forcing prices to remain low.

Conversely, aluminum producers operated at over 90 per cent of capacity as the price of primary ingot reached a record high of US 76 cents versus US 66 cents a pound at the beginning of the year.

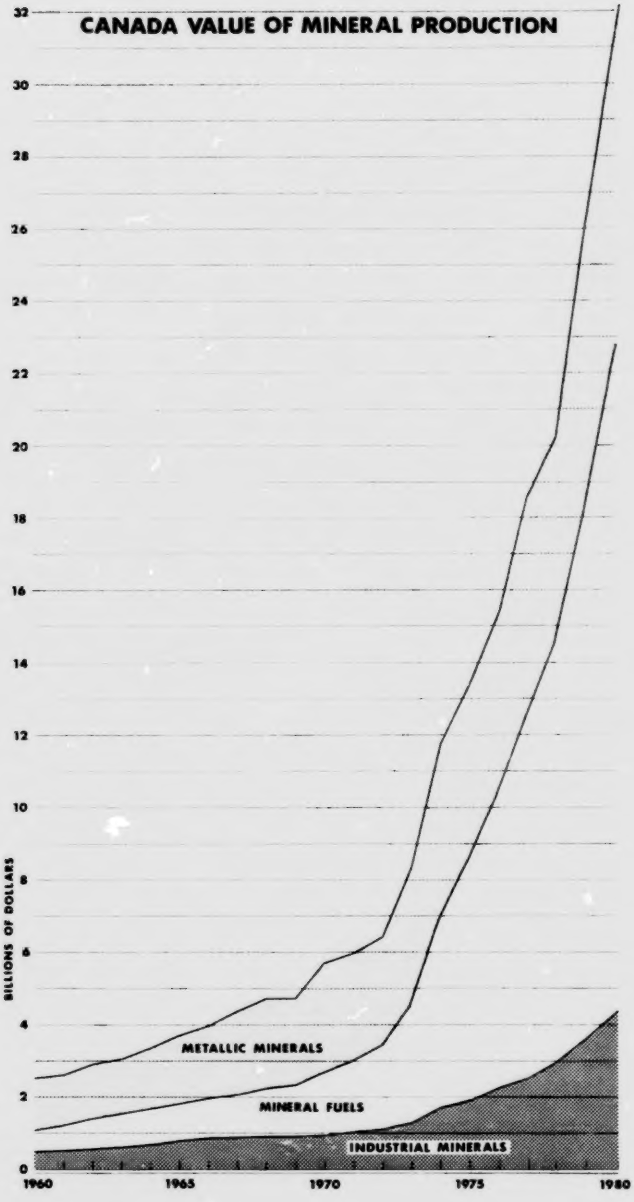

CANADA VALUE OF MINERAL PRODUCTION
BILLIONS OF DOLLARS
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
METALLIC MINERALS
MINERAL FUELS
INDUSTRIAL MINERALS
1960
1965
1970
1975
1980

Figure 5

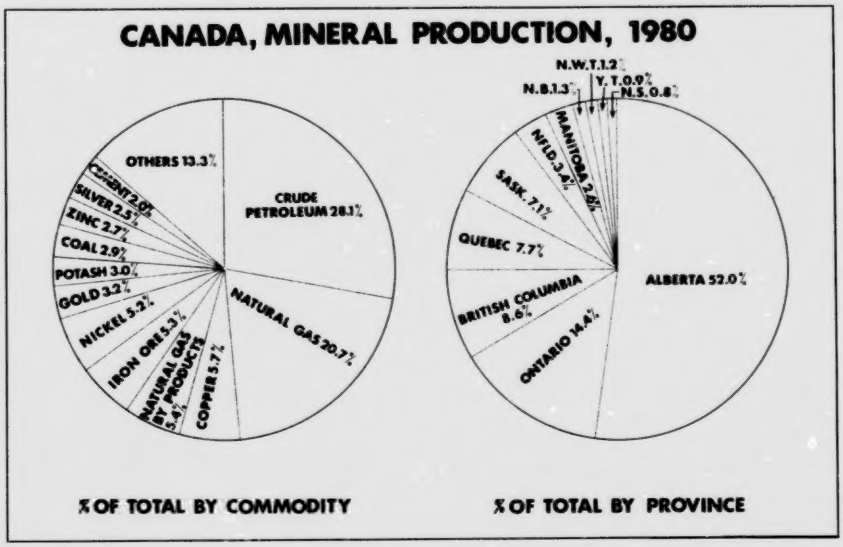


Figure 6

World markets for potash were also buoyant and the Potash Corporation of Saskatchewan (PCS) experienced a year of high sales and profits despite weak farm markets at home and abroad. In November, PCS announced a major expansion program, substantially increasing capacity levels to ensure its future market share.

The outlook for asbestos was not quite as bright as the industry continued to face pressures from safety and environmental groups. Declining sales and production cutbacks plagued asbestos producers in an already soft market. Reduced demand from a depressed construction industry in both North America and Europe contributed to an almost 11 per cent drop in output.

Canadian iron ore producers did not enjoy a boom year either. Dependent on export markets, the producers faced fierce competition as the economic slowdown reduced consumption to record low levels. The U.S. steel industry, depressed due to sluggish automobile and construction markets, did not foresee any significant improvement in the short term. As a result, little exploration activity or new mine developments took place during the year.

INTERNATIONAL TRADE

Canada continued to be the leading exporter in the world of non-fuel mineral commodities. Economic activity of other industrialized nations have a significant impact on the exports of Canadian minerals. During 1980, the export demand for minerals and mineral products continued to exhibit strong growth. Total value of mineral exports including fuels increased by 31 per cent over 1979 with nonferrous and nonmetallic minerals and mineral fuels increasing by 47 per cent,23 per cent and 27 per cent respectively.

The distribution of mineral exports by market remained relatively unchanged in 1980, as 71 per cent went to the United States, 7 per cent to Japan, 6 per cent to the EEC and 4 per cent to the United Kingdom.

Although Canada produces a variety of mineral commodities and is self-sufficient in most of these, it does import a number of the latter for geographical reasons, as well as importing a number of commodities not produced in the country. During 1980, the value of imported mineral commodities including fuels reached $16.7 billion, an increase of 34 per cent over 1979. The major increases in imports during 1980 were the nonferrous minerals, mineral fuels and the nonmetallic minerals.

INVESTMENT

Total investment, defined as capital and repair expenditures, in the Canadian economy increased by 11.3 per cent. Investment in manufacturing was $14 billion while that in mining reached $10 billion. Investment in metal mines increased from $1.6 billion to $2.2 billion. Two-thirds of the significant increase was attributable to increased investment in gold-quartz mines, copper-gold-silver mines and silver-lead-zinc mines reflecting the higher prices being paid for precious metals. In non-metal mining, investment rose from $0.8 billion to $1.0 billion. Mineral fuels experienced the second best increase going from $5.0 billion to $6.8 billion, an increase of 36 per cent. Investment in coal mines surpassed $300 million while investment in conventional crude oil and natural extraction reached the $5 billion mark.

Investment in mineral manufacturing also increased in 1980 with expenditures reaching a level of $3.5 billion. Primary metal manufacturing industries increased their investments by 36 per cent or $0.6 billion. The increased investment by iron and steel mills like that by smelters and refineries was $300 million. The level of investment in nonmetallic mineral products industries fell from $622 million to $604 million. While concrete product manufacturers reduced their investment by $10 million, ready-mix concrete manufacturers increased their by $18 million. Petroleum refineries increased their expenditures to $544 million in 1980.

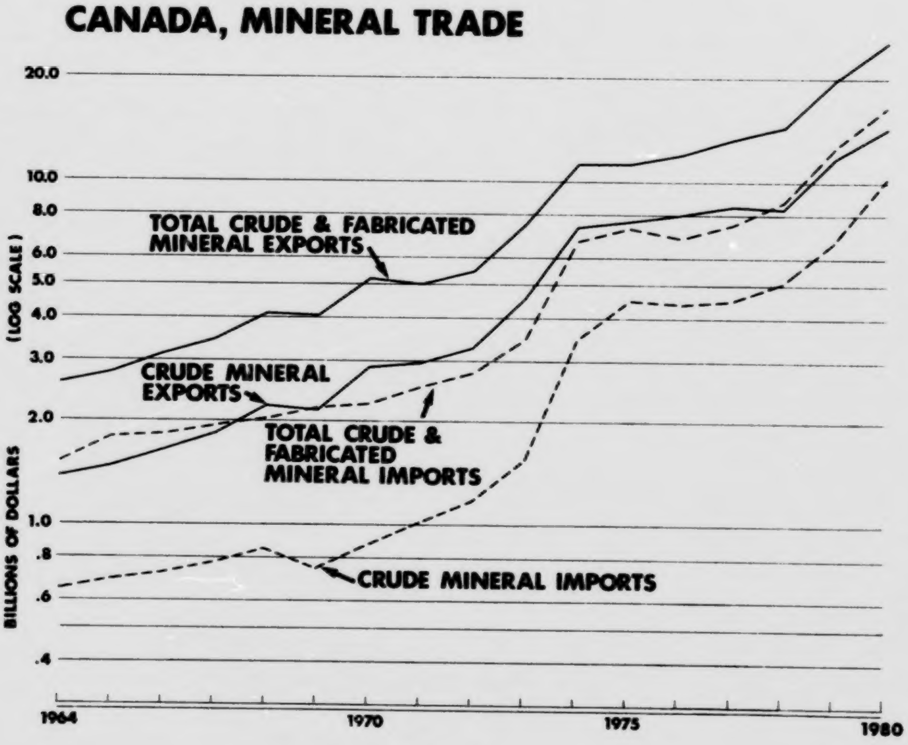


Figure 7

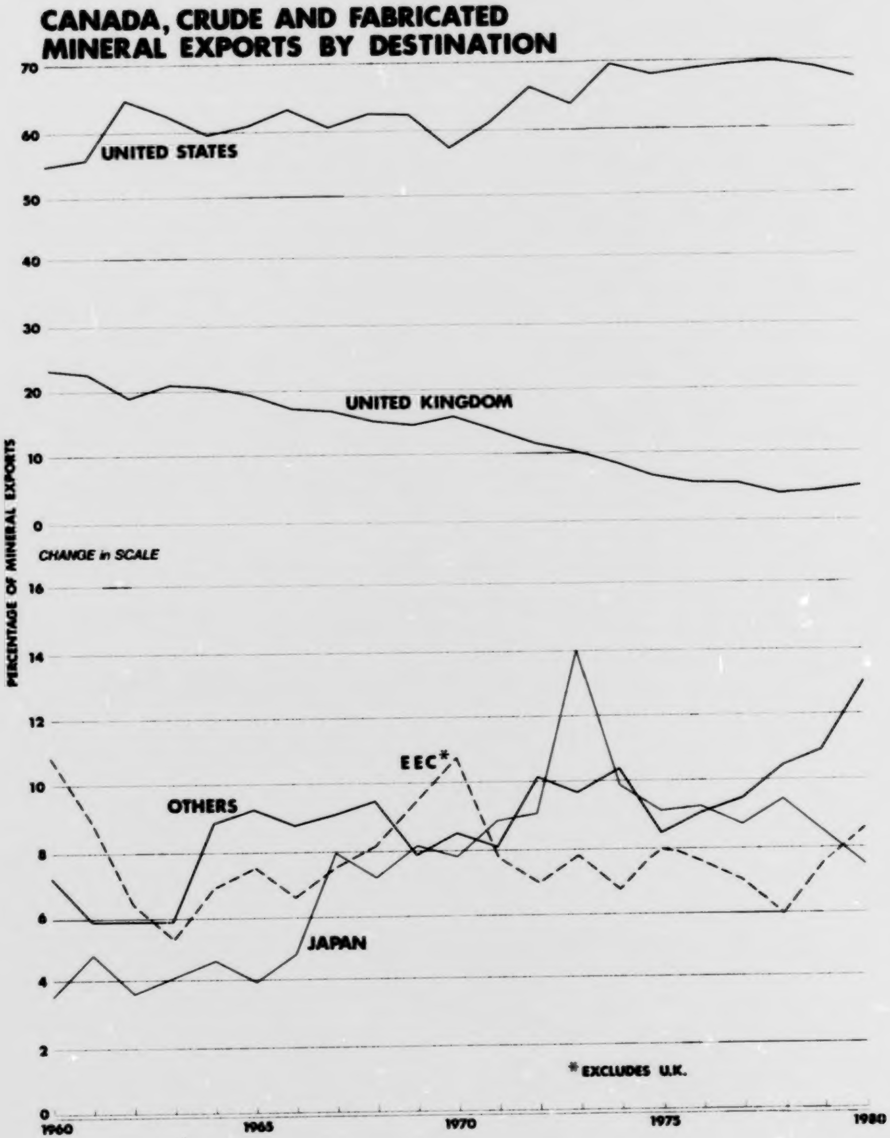
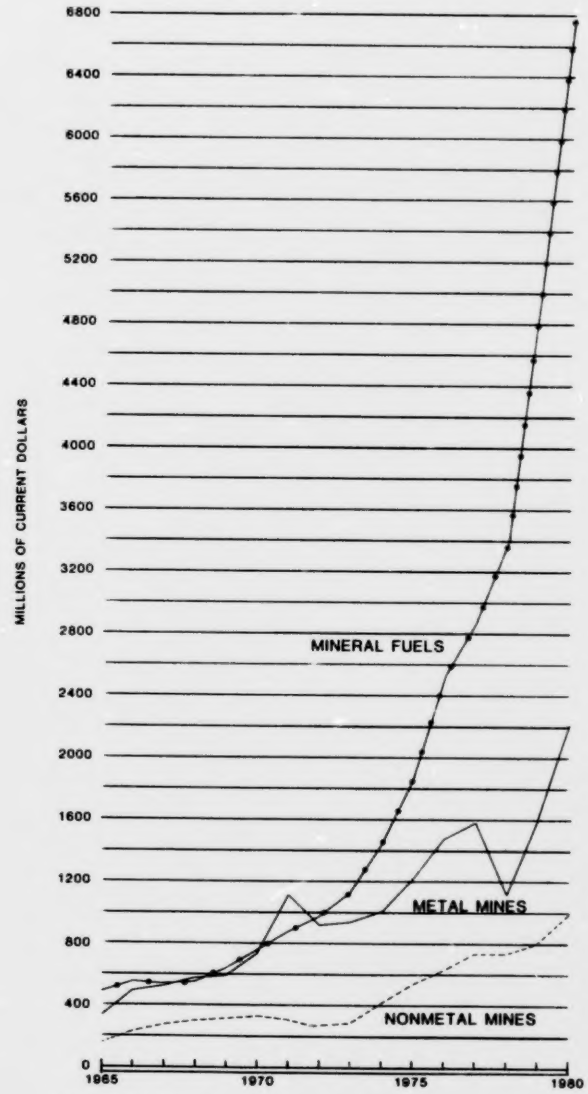

CANADA, CRUDE AND FABRICATED MINERAL EXPORTS BY DESTINATION
PERCENTAGE OF MINERAL EXPORTS
70
60
50
40
30
20
10
0
CHANGE in SCALE
16
14
12
10
8
6
4
2
0
UNITED STATES
UNITED KINGDOM
EEC*
OTHERS
JAPAN
* EXCLUDES U.K.
1960
1965
1970
1975
1980

Figure 8



CANADA, INVESTMENT* IN MINING BY SECTOR

* INCLUDES BOTH CAPITAL AND REPAIR EXPENDITURES

Figure 9

OUTLOOK FOR 1981 AND BEYOND

The outlook for the mining industry in this new decade depends to a large extent on the length and depth of the present world recession. Climbing interest rates, causing a weakening in consumer spending and demand for goods and services, makes the prospect for recovery a slow process. The speed of recovery will be closely tied to the performance of Canada's trading partners.

The United States spent most of 1980 in a recession, following a year of slow growth of only 2.3 per cent in 1979. Output declined over 1.5 per cent in 1980, suggesting that Canadian export markets, particularly for automotive and forest products, would be weak. In other world markets, similar problems existed. Japan faced a heavy current balance of payments deficit due to reduced demand in the United States, compounded by oil price increases. West Germany, while maintaining production levels, faced a substantial current account deficit on the services side and a rising inflation rate, though still well below that of most countries at a 6 to 7 per cent level. The British economy in 1980 was characterized by falling profits, rising unemployment and weak demand.

In this world environment, the general implications for Canada seem obvious. The pervasive influence of high cost oil has made its mark on all countries. The 1970s have been aptly named "The OPEC decade" and 1980 did not see any change in the importance of that sphere of influence. In 1981, Canada will likely experience another year of double digit inflation, rising unemployment and very weak economic growth. The Conference Board of Canada reported at the end of 1980 that economic growth would be just 1 per cent in 1981, representing a continued under utilization of Canada's resources.

Recovery will be a very slow process with any real growth occuring in the latter half of the year.

Given this bleak outlook, the industry will face a difficult task. In the past few years, it has managed not only to survive but has enjoyed modest growth and prices, though losing strength in the last half of 1980, continued to keep most commodities in profitable positions. But recession will eventually take effect, depressing many markets for mineral products. High precious metal prices and the lower Canadian dollar have managed to cushion the effects on profits, but the predictions of continued strong growth for 1980 after the boom of 1979 were not met.

However, mining entered the recession on a high note. Strong consumer demand in 1979 and record high prices for most base-metals provided a strong financial base. Producers, still well aware of the lean years prior to 1979, learned to react more quickly to lower sales by production cutbacks. Commodities such as iron ore and molybdenum have been hit particularly hard and concerns of oversupply are valid.

Overall, the industry faces a difficult decade. The 1970s were not particularly kind. The contribution of the non-fuel industry including mining and mineral processing to the economy slipped in terms of most national economic indicators. Data for 1970, 1974 and 1978 indicated that the impact of the industry in terms of GNP, labour force, wages and salaries, capital expenditures, exports and imports has declined. The non-fuel mineral industry is forecast to grow at an average annual rate of 2.45 per cent over the present decade and 1980 was an encouraging start for this important resource sector.

The economies of North America, western Europe and Japan are definitely slowing down. OPEC's price hikes along with restrictive economic policies that western countries have adopted to fight inflation and balance of payments problems have certainly taken their toll. The future is more uncertain than ever, but the mining industry appears to be prepared to face a bleak 1981.

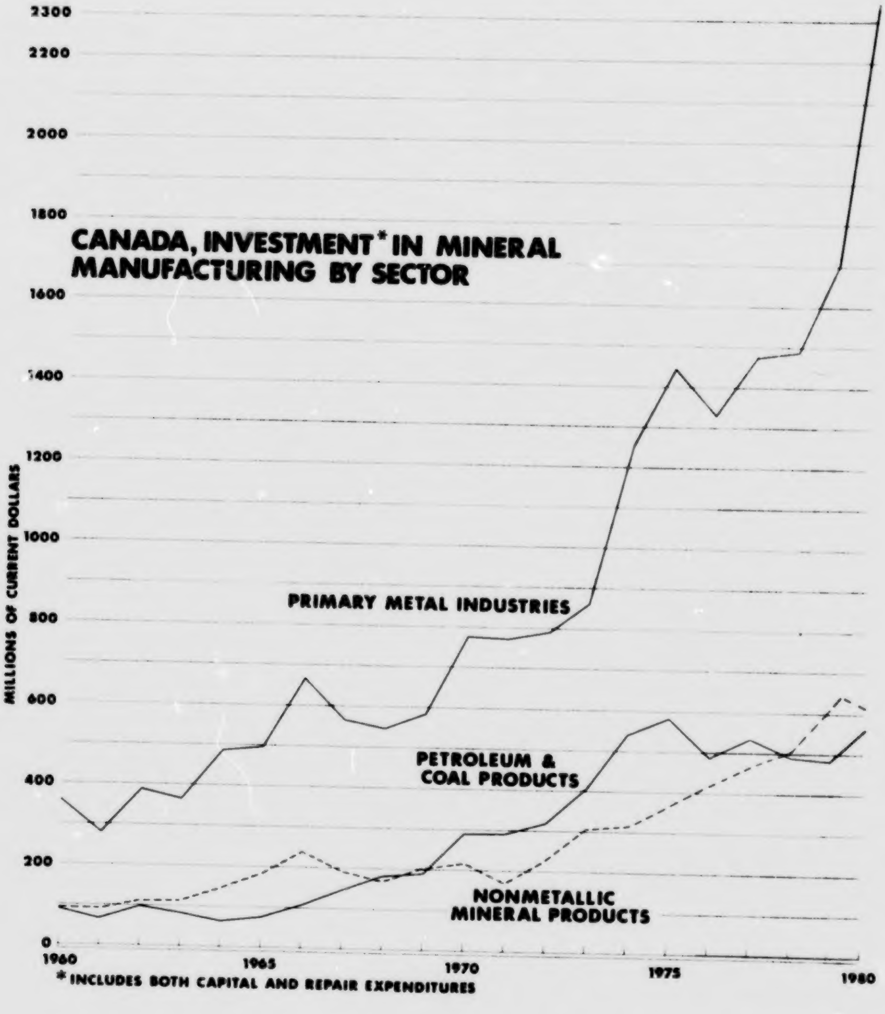

CANADA, INVESTMENT* IN MINERAL MANUFACTURING BY SECTOR
MILLIONS OF CURRENT DOLLARS
2300
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1960
1965
1970
1975
1980
PRIMARY METAL INDUSTRIES
PETROLEUM & COAL PRODUCTS
NONMETALLIC MINERAL PRODUCTS
* INCLUDES BOTH CAPITAL AND REPAIR EXPENDITURES

Figure 10

Regional Review, Canadian Mineral Industry

T.M. BUCH

The value of production of Canada's mineral industry increased 22 per cent, or $5.8 billion in 1980. More than 56 per cent of the increase, or $3.3 billion, was accounted for by oil, natural gas and coal. The near-doubling of the value of production of gold, silver and nickel was also significant.

For the nonenergy mineral industry, 1980 was more successful than the previous year when the physical output of most commodities declined, or at best remained stable. Nickel and copper production rose in both output and value compared with 1979. Soaring gold prices were responsible for a near-doubling in value on a slightly decreased quantity of production. Uranium also increased in value and in quantity produced. Both zinc and iron ore production declined in output and value compared with 1979.

Among the nonmetals in 1980, asbestos declined in output but increased in value, but most others including salt and gypsum increased on both counts, with potash and especially sulphur increasing quite strongly in terms of value.

Structural materials, which do not enter greatly into international trade, declined in physical output in 1980, compared with 1979, reflecting the relatively stagnant state of the domestic economy. However, most showed moderate increases in value, reflecting the other national problem - inflation.

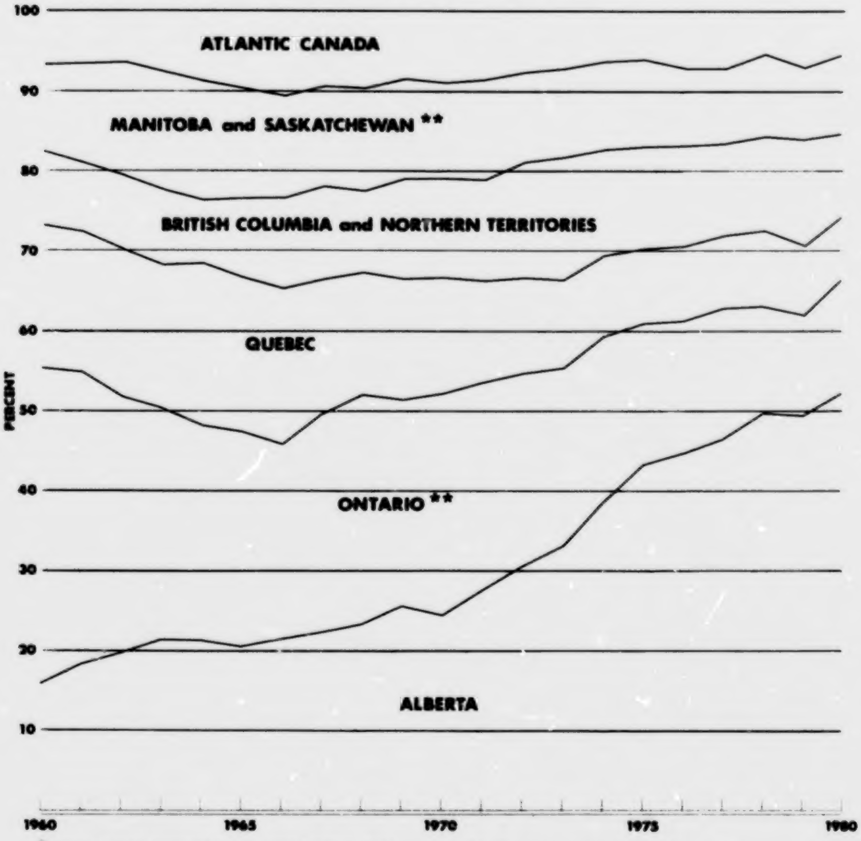
NEWFOUNDLAND

Mineral industry activity in Newfoundland in 1980 was mixed. Total output was $1.035 billion, down 8 per cent, as iron ore production fell 18 per cent in volume and 8 per cent in value, and companies laid off workers during the summer. Operations at the Buchans lead-zinc mine continued to wind down, but exploration activity was very strong. This strength was indicated by the record number of claims staked during the year, more than 11,500 by November, resulting in over 20,000 claims in good standing, compared with 14,500 in 1979.

Exploration was encouraged by the vigorous activity of the provincial Mines and Energy Department, in part funded under the Canada-Newfoundland Mineral Development Subsidiary Agreement. Four years into this five-year, $12 million agreement, designed to improve the geoscientific knowledge base in Newfoundland and Labrador, provincial geologists have already exceeded program targets; bedrock geological map coverage is available for 60 per cent of insular Newfoundland and 30 per cent of Labrador.

A number of companies were active during the year, notably Westfield Minerals Limited, which continued its uranium exploration program in the western part of the island. This company also entered a joint venture agreement with Shell Canada

PROPORTIONAL SHARE OF MINERAL PRODUCTION BY PROVINCE AND REGION, 1960–1980*



**Based upon current dollar production data reported in the accompanying table*
***Does not include uranium prior to 1977*

Resources Limited. Another drilling program was started in the western part of the island to evaluate possible potash resources where an exploration program in the late 1960s had indicated its presence in a geological environment similar to that in the New Brunswick potash deposits.

At Buchans, in central Newfoundland, work continued on the ASARCO Incorporated plant toward production of barite from mine tailings, for use in offshore oil well drilling mud in 1981. In the meantime, some metallic mineral production continued from the mine, which had been scheduled to close in 1979, and a deep zone exploration drilling program was in progress. Test material was being trucked to the concentrator in order to evaluate a nearby base-metal discovery.

In May 1980, the Newfoundland government accepted the recommendation of the Kitts-Michelin Environmental Assessment Board to withhold a development licence until the operating company, Brinex Limited, can demonstrate the safe disposal of radioactive waste from its proposed uranium mine and concentrator.

NOVA SCOTIA

The value of mineral production in 1980 was $247 million, up from $209.6 in 1979, primarily because of a 26 per cent increase in coal production, the value of which accounts for 54 per cent of the total. Nova Scotia is Canada's largest producer of gypsum, second-largest producer of salt and third-largest producer of coal.

The start of the federal-provincially funded development work for the proposed Donkin-Morien coal mine to tap offshore coal deposits was the major highlight for 1980 in the Nova Scotia mineral industry. Site preparation was completed and a contract awarded for engineering services for tunnelling work, to begin early in 1981. Initial work, at a cost of about $30 million, will consist of two parallel tunnels at a 15 degree slope for 3.5 km to evaluate seams previously identified under the $12 million federal-provincial offshore drilling program carried out in 1977 and 1978. Total cumulative cost if a mine is constructed will be over $400 million, with the coal to be used to fire additional thermal-electric generating stations, designated Lingan 3 and 4. In other significant coal developments, the province awarded a five-year contract to produce nearly 200 000 tpy of coal from a surface pit at Point Aconi on Cape Breton Island.

Over the past year, several nonfuel mineral exploration programs were in operation. The most significant in terms of potential impact to the province is Shell Canada Resources Limited's tin prospect 40 km from Yarmouth. Over the past four years, the company has spent $2.7 million and identified a deposit estimated at more than 20 million t containing 0.2 per cent tin. Additional drilling and metallurgical tests and mine feasibility studies are required before the economic significance of the property can be determined.

The combined value of lead and zinc produced in the province was more than $5 million in 1980. Both the Gays River mine of Canada Wide Mines Ltd., a subsidiary of Esso Minerals Canada, and the Yava Mines Limited deposit of Barymin Explorations Limited achieved significant production, following start-up late in 1979.

NEW BRUNSWICK

The value of mineral production in 1980 was $372 million, down from $480 million in 1979 because of four-month strikes at the Brunswick Mining and Smelting Corporation Limited base-metal mine and smelter operations in the Bathurst area. These disputes led to decreases in the amount of zinc, lead and silver produced. However, the high price of silver, particularly in the first quarter, meant that the decrease was less than expected. Together, zinc, lead and silver accounted for 71 per cent of the value of mineral production.

Potash exploration and development dominated the mineral industry in New Brunswick in 1980. Northeast of Sussex, Potash Company of America was sinking the second of two shafts, constructing refining facilities, and evaluating mining and refining techniques, for start-up expected in 1982. Southwest of Sussex, Denison Mines Limited nearly completed sinking its first shaft for what could become the province's second potash mine by 1983. BP Canada Inc. entered into an agreement with the province to explore and develop a third deposit west of Sussex.

In the metallics sector of the New Brunswick mineral industry, several significant events took place during the year. Construction of the Mount Pleasant tungsten-molybdenum mine, a joint venture between Brunswick Tin Mines Limited and Billiton Canada Ltd. was on schedule for start-up by late 1982. At its Lake George antimony mine, Consolidated Durham Mines & Resources Limited announced discovery of a new orebody. Reserves are estimated at 800 000 t grading more than 3 per cent antimony.

The oil shale potential of the Albert formation has been explored by Canadian Occidental Petroleum Ltd. (Oxy) for several years. So far, Oxy has evaluated 405 hectares and found uniform oil shales containing eight to 10 per cent hydrocarbons. Feasibility studies on methods of extraction were being conducted, although the resource will remain uneconomic until domestic oil prices approach world levels.

QUEBEC

The total value of mineral production in Quebec increased by 14 per cent to $2.467 billion in 1980. Gold dominated the mining development news as it moved from fifth to third place in value of mineral production with an increase in value of 105 per cent over the 1979 level to $358 million. The amount of gold produced in 1980 was 15.6 million grams, up 0.8 million g, or 6 per cent, over 1979. Milling capacity that had been standing idle in previous years was fully used in 1979 and additional gold mine production in 1980 brought with it new and expanded gold mills. A gold circuit was added by Campbell Resources Inc. to handle ore from the Gwillim mine and Agnico-Eagle Mines Limited spent $1 million on the Eagle mill to bring it to a 1 200 tpd milling rate.

Plans were announced for 1981 for a 1 360 tpd mill for the Belmoral and Bras d'Or gold mines, a 910 tpd gold mill at the Doyon mine, an additional $750,000 to further upgrade the mill and crushing plant at the Eagle gold mine, an increase in capacity of 600 to 1 000 tpd at Les Mines Est-Malartic Ltée mill, an increase from 910 to 1 450 tpd at Les Terrains Aurifères Malartic (Québec) Limitée mill, and modifications to Noranda Mines Limited's Horne concentrator to treat zinc and copper ore from Les Mines Gallen Limitée and New Insco Mines Ltd.

In 1980, the Gwillim gold mine, the Doyon gold mine and the Corbet copper-zinc-silver-gold mine came into production in Quebec. Announcements were made concerning the development of the Kiena Gold Mines Limited, Les Mines Gallen zinc-copper mine and the New Insco copper mine. Selbaie was developing its high grade copper B zone for production in 1981. Campbell Resources Inc. was sinking an internal shaft to a new copper-gold-silver orebody, Agnico-Eagle was sinking a 1 200 m shaft on the Telbell Mine adjacent to the Eagle mine, and Camflo Mines Limited started developing the Malartic Hygrade Gold Mines Limited property from the Camflo workings. Development work continued on the huge salt deposits of the Madelaine Islands.

Improvements to the metallurgical process at its smelter were announced by Noranda Mines Limited. The $35 million program includes the construction of a 350-450 tpd oxygen plant and minor modifications to improve efficiency, working conditions and the environment through a reduction in dust emissions.

Alcan Aluminium Limited completed the first stage of its $500 million aluminum smelter complex at Grande Baie with the start-up of 26 pots (57 000 t). Two additional potlines of the same size are planned for 1981 and 1982. Alcan also announced a $13 million expenditure for environmental control equipment at the Beauharnois smelter.

ONTARIO

Ontario's mineral industry, one of the most diversified among the provinces, saw growth in output and value of most commodities in 1980, with total output valued at $4.640 billion, up 30 per cent compared with the previous year. The platinum group of metals lead the field, up 108 per cent in output and 182 per cent in value; they were followed by nickel, up 65 per cent in quantity and 104 per cent in value both reflecting 1979s strike-impaired performance of mines in the Sudbury district. Gold's performance was also spectacular, down 789 million g, or 4 per cent in volume, but up 91 per cent in value. Copper and uranium were also up in both output and value, whereas iron ore, magnesium, cement and salt were up only in terms of value. Cobalt and zinc were down on both counts.

The year was a very active one for the exploration industry in Ontario. In the Kirkland Lake area, for example, it opened with companies following up on ground acquisition that had taken place in the staking rush the previous fall. This rush stemmed from the release of maps of airborne geophysical data obtained from work done under the shared cost federal-provincial Kirkland Lake Incentives Program. Exploration activity was further encouraged throughout the province by the rise in the price of gold. Some new and apparently significant discoveries of gold were reported, but most of the action consisted of drilling and underground exploration of known deposits, re-examination of former producers, and announcements of the reactivation of old gold mines.

One new gold discovery was the Hoyle Pond deposit, found by Texasgulf Metals Company beneath its tailings pond at Timmins. Reported to contain visible gold, it is said to be of a different type from the nearby Owl Creek disseminated gold deposit, on which a decline has been driven.

TABLE 1. CANADA, PROVINCES AND TERRITORIES, LEADING MINERALS, 1980

	Value of production ($ million)	Proportion of total (%)	Change from 1979 (%)
Newfoundland			
Iron ore	895.6	86.5	-7.1
Asbestos	45.2	4.4	24.6
Zinc	42.8	4.1	-15.3
Total	1,035.6	100.0	-7.9
Prince Edward Island			
Sand and gravel	2.3	100.0	17.4
Total	2.3	100.0	17.4
Nova Scotia			
Coal	133.2	54.0	33.7
Salt	26.9	10.9	16.4
Sand and gravel	24.4	9.9	4.9
Gypsum	22.5	9.1	-14.9
Total	246.7	100.0	17.7
New Brunswick			
Zinc	131.7	35.4	-36.1
Silver	90.6	24.3	16.1
Lead	46.3	12.4	-51.9
Copper	23.6	6.3	-14.5
Total	372.5	100.0	-22.3
Quebec			
Iron ore	531.0	21.5	-2.3
Asbestos	495.5	20.1	-2.0
Gold	358.0	14.5	110.5
Copper	253.7	10.3	33.4
Total	2,466.8	100.0	14.0
Ontario			
Nickel	1,154.9	24.9	103.9
Copper	673.3	14.5	47.2
Uranium	463.5	10.0	23.3
Gold	423.2	9.1	91.1
Total	4,640.5	100.0	42.1
Manitoba			
Nickel	342.6	42.7	30.6
Copper	168.1	20.9	21.6
Petroleum	55.0	6.9	13.6
Cement	34.7	4.3	-23.8
Total	802.6	100.0	23.0
Saskatchewan			
Potash	1,020.7	44.1	38.8
Petroleum	864.0	37.3	18.5
Uranium	238.6	10.3	-0.1
Total	2,314.6	100.0	23.5

TABLE 1. (Cont'd.)

	Value of production	Proportion of total	Change from 1979
	($ million)	(%)	(%)
Alberta			
Petroleum	7,905.4	48.3	21.9
Natural gas	5,748.7	35.1	16.9
Natural gas byproducts	1,789.9	10.9	27.1
Total	16,379.0	100.0	27.0
British Columbia			
Copper	687.1	24.6	6.5
Coal	445.4	15.9	-8.7
Natural gas	304.2	10.9	-22.5
Molybdenum	281.5	10.1	-12.4
Total	2,795.3	100.0	2.7
Yukon Territory			
Silver	114.1	31.6	110.5
Zinc	88.3	24.4	-19.3
Lead	71.6	19.8	-30.8
Total	361.3	100.0	20.7
Northwest Territories			
Zinc	172.6	40.7	-16.1
Gold	96.9	22.8	56.7
Lead	55.9	13.2	-30.3
Total	424.5	100.0	8.5
Canada			
Petroleum	9,037.9	28.4	21.3
Natural gas	6,148.8	19.3	26.6
Copper	1,859.6	5.8	23.1
Natural gas byproducts	1,825.1	5.7	26.0
Iron ore	1,700.9	5.3	-5.9
Nickel	1,497.4	4.7	80.7
Gold	1,165.4	3.7	97.3
Potash	1,020.7	3.2	38.8
Coal	932.0	2.9	8.4
Zinc	858.2	2.7	-19.0
Total	31,841.8	100.0	22.1

Source: Energy, Mines and Resources Canada.

Work also continued on the Amoco-Dome-Campbell gold deposit at Detour Lake, 80 km northeast of Cochrane to determine if this deposit is mineable. Reported to contain more than 27 million t grading 3.89 a t, it is the largest known gold deposit in Canada. It was announced that for a capital investment of $143 million, a 2 000 tpd mine-mill complex is to be in operation by 1983.

Near Sioux Lookout, Goldlund Mines Limited announced an agreement with Hollinger Argus Limited that could see a 500 tpd mine and mill established on the property of this previous producer. On an adjoining property, drilling by Windfall Oils & Mines Limited was reported to have intersected an extension of the Goldlund deposit. Also in northwestern Ontario, shipments were made of previously milled material from the old Leitch mine near Geraldton to the Lamaque facility at Val d'Or, Que. Late in the year, it was announced that financing was being sought to reopen the former Paymaster mine at Timmins.

Existing gold mines and mills also benefitted from the high price of gold. Some, such as Dome Mines, Limited, announced expansion plans during the year, including sinking a new shaft and increasing milling capacity to 3 000 tpd. Pamour Porcupine Mines, Limited was in the process of expanding capacity to 7 000 tpd. The company has an active policy acquiring rights to known gold deposit in the neighbouring district, including the No. 3 mine, the Ross, the Timmins, and the Romfield, with other properties being examined and developed. In the Red Lake area, Campbell Red Lake Mines Limited expanded its facilities during the year, and Dickenson Mines Limited continued to add to its ore reserve position.

Among the base metal mines, Selco Inc.'s South Bay mine in northwestern Ontario had a good year in 1980 but was facing closure unless new reserves were found. At Timmins, Texasgulf Inc. was enlarging its zinc plant and the company announced the start of work on a precious metals refinery. Construction of the new copper smelter-refinery continued.

Caland Ore Company Limited of Atikokan laid off most of its work force in the spring.

At Cobalt, both Agnico-Eagle Mines Limited and Teck Corporation continued to produce silver and cobalt. The generally higher silver price and relatively high price for cobalt encouraged further exploration of old properties and the rehabilitation of old workings. In fact, Teck entered a joint venture on a Consolidated Summit Mines Limited property adjoining its Silverfields operation shortly before year-end.

Spokesmen for Canada's uranium mining industry, still predicted a bright future for the metal, although the price continued to decline during 1980.

The Ontario government phased out its Mineral Exploration Assistance Program (MEAP) in favour of a new, more comprehensive program: the Ontario Mineral Exploration Program (OMEP). Effective September 1980, this program allows for cash grants or income tax credits up to a maximum of $250,000 and is applicable throughout the province. MEAP, on the other hand, had a maximum of $33,333 per property and could be applied for only in designated areas.

The year saw the first season of work under the $4 million Minerals Program of the $50 million federal-provincial Eastern Ontario Subsidiary Agreement. A number of mapping parties were in the field and programs to assess industrial minerals and construction materials were started. It was anticipated that the area of the agreement, most of Ontario east of Haliburton and Peterborough counties, will be covered by an airborne gradiometer survey. Under the agreement the technology, developed by federal government scientists of the Geological Survey of Canada, was to be transferred to the private sector.

MANITOBA

Total mineral output in Manitoba was $803 million, up 23 per cent in 1980. Nickel and copper, which constitute nearly two-thirds of the total, were up 31 and 22 per cent respectively. Most of the increase for nickel and much of that for copper can be attributed to increased metal prices as the production was up only 3 per cent for nickel and 11 per cent for copper.

Exploration expenditures which started to pick up in 1978 continued to increase through 1980. The Manitoba government estimated 1980 exploration expenditure at $31 million, up 87 per cent from $16.6 million in 1979. Base-metal exploration around mining belts and in the Sherridon area accounted for most of this activity. The very rapid rise in the price of gold encouraged exploration activity and some previous gold producers were being re-evaluated. Exploration programs for tantalum, uranium, potash, and oil and gas were also conducted in 1980.

Hudson Bay Mining and Smelting Co. Limited had a number of mines under development. Under a lease from Falconbridge Nickel Mines Limited and Stall Lake Mines Limited, Hudson Bay will be spending $14 million to develop the small, high-grade Rod mine. Production is expected by January 1983. Hudson Bay was also developing, at a capital cost of $16 million, the Spruce Point mine 37 km southeast of Flin Flon for production in 1982. Both these mines will ensure a supply of ore to the Stall Lake

TABLE 2. EMPLOYMENT STATISTICS IN MINING[1] BY PROVINCE, 1978-80

	Nfld	NS	NB	PEI	Que	Ont	Man	Sask	Alta	BC	YT & NWT	Canada
						(000)						
Mining employ't[1] 1978	4.7	4.9	2.9	..	21.7	30.0	5.6	7.1	45.5	14.3	3.0	139.7
% of total province	3.6	2.0	1.5	..	1.0	0.9	1.6	2.8	6.0	1.6	9.0	1.7
Total prov. employ't[2]	131.5	244.9	188.2	30.0	2 116.6	3 377.5	345.5	255.9	753.9	915.0	33.5	8 392.5
Mining employ't[1] 1979	5.8	5.0	3.0	..	24.2	29.7	5.6	8.1	51.5	15.0	3.1	151.0
% of total province	4.2	2.0	1.5	..	1.1	0.9	1.6	3.0	6.4	1.6	8.5	1.7
Total prov. employ't[2]	138.0	254.9	196.3	31.5	2 204.2	3 438.1	355.5	268.0	810.8	957.4	36.6	8 691.3
Mining employ't[1] 1980	5.6	5.0	2.6	..	25.8	33.4	5.9	8.7	63.1	16.9	3.2	170.2
% of total province	4.1	1.9	1.3	..	1.2	1.0	1.7	3.2	7.3	1.7	8.4	1.9
Total prov. employ't[2]	137.4	259.4	198.8	31.8	2 219.1	3 486.5	355.6	274.6	866.2	1 009.0	38.3	8 876.7

Source: Statistics Canada.

[1] Mining, including milling, unadjusted. [2] Total nonagricultural employment, unadjusted.
.. Too small to be significant.

concentrator 5 km from Flin Flon. Hudson Bay was also investing $28 million in the development of the Trout Lake copper-zinc deposit, which will earn the company a 44 per cent interest in a joint venture with the Manitoba Crown corporation, Manitoba Mineral Resources Ltd. and Gränges Exploration AB. Production is anticipated by 1982 and the ore will be treated at the Flin Flon concentrator. In 1980, Hudson Bay also announced the expenditure of $48 million over the next three to four years for improvements to its copper smelter, zinc plant and associated environmental control equipment.

Tantalum Mining Corporation of Canada Limited had almost completed a $1 million expansion to its processing plant, increasing its capacity from 160 000 t to 227 000 tpy.

On the Agassiz gold prospect, Sheritt Gordon Mines Limited had a feasibility study under way.

SASKATCHEWAN

Saskatchewan ranks fifth among the provinces in terms of the value of its mineral output, that in 1980 reached $2.315 billion and of which 81 per cent came from potash and petroleum production. Potash production increased in both quantity and value and, for the first time, surpassed that of petroleum, which increased only in value. The province produced 34 per cent of Canada's uranium, almost all of its sodium sulphate and all of its potash.

Exploration and development activity in the uranium sector continued at high levels during 1980. At McClean Lake, Canadian Occidental Petroleum Ltd. and Inco Metals Company delineated an estimated 6.4 million kg of uranium oxide and were studying mining methods. Gulf Minerals Canada Limited announced discovery of a uranium deposit 13 km north of its Rabbit Lake mine. Discovery of a fourth mineralized zone on its Dawn Lake property west of the Rabbit Lake mine was announced by Asamera Inc. Esso Minerals Canada was preparing an environmental impact statement for the provincial government on proposed development of the Midwest Lake uranium deposit to the west of the Dawn Lake property. Formal public hearings began in June on proposed development of the Key Lake deposit north of La Ronge, controlled by the Crown corporation, Saskatchewan Mining Development Corporation which is expected to be in production in to be in production in 1983 at 5.4 million kg of uranium oxide per year.

Activities in uranium mining and processing were highlighted by Amok Ltd. bringing on-stream its Cluff Lake mine and concentrator at an initial design rate of 2 million kg of uranium oxide per year. After lengthy public hearings where negative views were expressed, Eldorado Nuclear Limited dropped its option to purchase land for a uranium refinery at Warman, near Saskatoon.

The potash industry continued to show strong activity in 1980 with several planned expansions and one new mine announced. The Potash Company of America announced a mine expansion near Saskatoon from 635 000 to 910 000 tpy of product. The Crown corporation, Potash Corporation of Saskatchewan (PCS), intends to construct a new mine at Bradenbury, near the Manitoba border, that would be completed by 1986 and have a capacity of 3.26 million tpy of product. PCS will also take over operation in 1981 of the Allan mine, in which it holds a 60 per cent interest. Further progress was made in diversifying and expanding Saskatchewan potash markets with the signing of an agreement between Canpotex Limited, the producer export agency, and the People's Republic of China for shipments of approximately 650 000 tpy of product effective January 1, 1981.

ALBERTA

Alberta's mineral production was $16.379 billion, an increase of 27 per cent in 1980. This took place in the face of production declines of 4 per cent in petroleum and 6 per cent in natural gas, although value of output increased 22 per cent and 30 per cent, respectively. Coal output increased by 2.3 million t, or 15 per cent in quantity and by $64 million, or 27 per cent in value.

Although best known for its oil and gas production, Alberta also leads the country in coal production. Even though coking coal markets were soft, growth was expected in thermal coal production. By the end of the century, Alberta hopes to increase its portion of electricity generated from thermal coal to 80 to 85 per cent from the present level of 75 per cent. This coal will come from various sources, including production increases at some of the six major thermal mines and various smaller mines, and the development of the Sheerness coal mine.

Approval was granted by the Alberta Energy Resources Conservation Board for a $400 million open-pit thermal coal mine and processing plant on the Obed Marsh property, near Hinton, by Union Oil Company of Canada Limited directed at the export market. Production could begin in 1983 and rise to the design capacity of three million t of saleable coal. Other new mines were being considered by the Alberta Energy Resources Conservation Board at Shaughnessy, Judy Creek and at Kipp, where coal is being developed to test markets and mining methods.

Increases in metallurgical coal production will come from McIntyre Mines Limited's No. 9A mine and a new mine southwest of Hinton owned by Gregg River Coal Ltd., a subsidiary of Manalta Coal Ltd. Development of two new zones at the McIntyre No. 9A mine neared completion at the end of 1980. By 1983, two million tpy of coal will be going to Japan from the $180 million Gregg River mine under the terms of a contract negotiated in 1980. An expansion was planned at the Sheerness thermal coal mine, a strip operation 135 km east of Calgary, to feed an on-site power plant to come on-stream in 1985. Other expansions are being considered by the Alberta Energy Resources Conservation Board at Highvale and Coal Valley.

Final approval for the Alsands oil sands project and the Cold Lake heavy oil project was being withheld by the Alberta Cabinet pending resolution of a comprehensive oil pricing agreement.

BRITISH COLUMBIA

British Columbia is third in the value of mineral production in Canada at $2.795 billion, up only marginally from $2.677 billion in 1979. Of the province's leading minerals only copper increased in value, up 6 per cent over 1979, primarily because of higher prices. Decreases occurred in coal and molybdenum because of lower prices and in natural gas because of a drop in production volume even though prices increased.

Coal was perhaps the most active sector of the mineral industry in British Columbia in 1980. There were lengthy but inconclusive negotiations for northeast coal development among the federal and provincial governments, the mining companies, the railways and potential Japanese markets. This would be a huge project, involving initially two mining companies, construction of a 115 km spur rail line and rolling stock, rail line upgrading to Prince Rupert, construction of port facilities, and establishment of a new townsite. Coal developments in the southeast region in 1980 included Fording Coal Limited's plans to expand coking coal production at Elkford, and a new coking coal mine by Kaiser Resources Ltd. near its present mine at Sparwood.

Several projects in the metallic sector of the mineral industry will have a significant economic impact upon various regions. In the Highland Valley, Valley Copper Mines Limited and Bethlehem Copper Corporation began joint studies to develop their jointly owned Lake Zone copper deposit, which, when completed, would be the largest copper mine in Canada. Lornex Mining Corporation Ltd. was expanding its mine to increase production by about 68 per cent by mid-1981. Also, in the Highland Valley, construction of the Highmont Mining Corporation copper-molybdenum mine was nearly completed for production early in 1981. In the north-central region, the Sam Goosly silver mine of Placer Development Limited began production in the fall of 1980. In the southeast region, Noranda Mines Limited announced that it will develop its Goldstream River copper-zinc deposit for production in 1983. AMAX Inc. was refurbishing the Kitsault molybdenum mine in the northeast region to begin operation by mid-1981.

In early 1980, the province imposed a seven-year moratorium on future uranium exploration and development, pre-empting any recommendations from the Bates Commission, which had been established earlier. Most directly affected are the Rexspar and Blizzard Mountain properties, both in the southeastern region. The companies involved were permitted to retain ownership of their leases over the term of the moratorium. The provincial government decided that the environmental costs outweigh the potential benefits of uranium development in the province.

NORTHWEST TERRITORIES

Mineral production in the Northwest Territories fell 3 per cent to $424 million in 1980. Output of most commodities was down; both lead and zinc dropped 15 and 17 per cent, respectively, in volume in 1980, which, combined with a decrease in lead prices of nearly 20 per cent reduced the value of lead produced by 30 per cent. Gold output also fell in 1980, in part due to a three month strike at the Giant Yellowknife Mines Limited mine, although the value of production rose 57 per cent.

The Camlaren gold mine of Discovery Mines Limited started production under a lease-royalty arrangement with Noranda Mines Limited and Pamour Porcupine Mines, Limited. IU International Corporation announced in September its intention to spend $115 million to bring their Contwoyto Lake gold property into production by 1982 at a rate of 910 tpd. Financing for the Cullaton Lake Gold Mines Ltd. of Consolidated Durham Mines & Resources Limited and O'Brien Energy & Resources Limited was arranged with the Inuit Development Corp. Production was planned to start by September 1981. Echo Bay Mines Ltd., a subsidiary of IU International Corporation, reopened the Contact Lake and Bonanza mines near Port Radium.

In other development work, the concentrator from the old Churchill copper mine in northern British Columbia was being refurbished for installation at the Cadillac Exploration Limited's silver-lead-zinc property. Construction of the barge and concentrator was begun in Quebec for the Polaris lead-zinc mine Arvik Mines Ltd. Mine development should begin in November 1981 and production at a rate of 2 000 tpd by January 1982. The Cullaton Lake, Polaris, Contwoyto Lake, Cadillac and Polaris projects will increase the value of mineral production in the Northwest Territories by 25 per cent.

Uranium dominated the exploration scene in 1980 although gold exploration increased significantly. The Department of Indian and Northern Affairs estimated 1980 exploration expenditures at $30 million in 1979.

YUKON

The economic activity of the Yukon territory continued to be dominated by its three non-fuel mines. The value of mineral production in 1980 was $361 million, up from $299 million in 1979. Gold production was valued at almost $59 million, compared to $13.7 million the previous year, because of the high price of gold in 1980. Placer gold accounted for almost two-thirds of the volume of gold produced.

Exploration expenditures were estimated by the Department of Indian and Northern Affairs to have been $32.8 million in 1980, up significantly from approximately $20 million in 1979. Most of the increase may be attributed to a second gold rush that the Yukon is experiencing. Base-metal exploration remained at 1979 levels.

During 1980, Cyprus Anvil Mining Corporation announced an eight-year, $240 million program for the Faro mine. Under this program the Grum and Vangorda lead-zinc deposits will be brought on-stream as open-pit mines, thus extending the life of the operation to the end of the century.

The Venus Mines of United Keno Hill Mines Limited was being refurbished for production in 1981. Gold-silver ore will be shipped to a new 90 tpd mill being constructed just across the border in British Columbia. United Keno Hill Mines also announced the construction of a $300,000 bullion refinery to be built at the Elsa mill to treat cyanide precipitates from the Keno Hill and Venus mines.

A government and industry study group was formed in December to expedite the development of the Mactung, Tom, Jason and Howard's Pass deposits in the MacMillan Pass area. On the Tom silver-lead-zinc-barite deposit, Hudson Bay Mining and Smelting completed 1 400 m of fill-in drilling in 1980, the first year of a three-year, $10 million program. Underground development will start in 1981. On the Jason property, Pan Ocean Oil Ltd. conducted trenching and about 5 000 m of diamond drilling, mostly on new targets, and a new zone of massive sulphides with high silver assays was found. Four drills will be engaged in 1981 in an intensive program that will attempt to bring this property closer to the same stage of evaluation as the Tom property. A feasibility study was being conducted on the Mactung deposit in preparation for a production decision in the second quarter of 1981. At the Howard's Pass deposit, an exploration adit was started by Placer Development Limited. Originally planned for completion in 1980, the adit and crosscuts may not be finished before 1982.

In other developments, AMAX Exploration, Inc. and Logtung Resources Ltd. completed a decline on the Logjam scheelite-molybdenite property. Metallurgical testing was under way. Cima Resources Limited awarded a contract for a final feasibility study on its Mount Hundere lead-zinc-silver property 55 km north of Watson Lake.

In the Bonnet Plume area, 210 km north of Mayo, a major drilling program in 1980 increased inferred reserves to 630 million t at Pan Ocean Oil's coal property. Two feasibility studies are planned: one will consider a 200 MW coal-fired thermal power plant near the coal deposits, and the other will examine the possibility of exporting coal using a slurry pipeline.

The Northern Mineral Advisory Committee was active throughout the year in advising the minister of Indian Affairs and Northern Development. A number of its recommendations were implemented. The moratorium on the taxation of northern allowances to individuals was extended for one year. More modern mineral legislation was being developed and changes will be made to the Yukon Quartz Mining Act and the Territorial Coal Regulations. A new royalty scheme for both the Yukon and the Northwest Territories was also being developed.

The federal government advanced a plan for assistance to the White Pass and Yukon Railway whereby $18 million in long term deferred interest loans would be split three ways among the Canadian and United States governments and Cyprus Anvil, the major user of the railway.

Canadian Reserves of Selected Mineral Commodities

(Data available as of 1980)

J. ZWARTENDYK

Any assessment of future supply of a given mineral commodity from Canadian mines requires information on current working inventories, i.e., on the amounts of ore known to be present in operating mines and on additional known tonnages in deposits that are close to being mineable profitably. The tonnages that - in 1980 - were fairly well delineated and judged to be economically mineable are reported below as "reserves". The limits of what is included in reserves are further specified in each case.

(A)	**Copper**	16 368 600 tonnes[1]
	Nickel	7 178 900 tonnes
	Lead	9 557 000 tonnes
	Zinc	28 634 600 tonnes
	Molybdenum	554 000 tonnes
	Silver	31 564 tonnes
	Gold	540 493 kilograms

The quantities of the metals listed above are contained in ore economically recoverable from producing mines and from deposits that had been committed for production up to January 1, 1980. These quantities represent measured and indicated tonnages and exclude inferred tonnages[2].

(B) Iron 2 400 million tonnes

This is the quantity of iron contained in known crude ore in producing mines and properties under development[3]. Ore in undeveloped deposits is not included.

(C) Asbestos 47.5 million tonnes

This represents the quantity of fibre recoverable (on average, a little over 5 per cent) from 885 million tonnes of economically mineable ore reserves in producing mines.

(D) Potash 14 000 million tonnes (K_2O equivalent), corresponding to 23 000 million tonnes KCl product (standard fertilizer - exported product).

This amount would be recoverable by conventional mining (to a depth of about 1 100 metres) from known potash deposits. At least an additional 42 000 million tonnes (K_2O equivalent) would be recoverable from known deposits by solution mining at depths beyond 1 100 metres; this would represent 69 000 million tonnes of KCl product.

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[1] The term "tonne" refers to the metric ton of 2 204.62 pounds avoirdupois.

[2] W.H. Laughlin, MR **189, Canadian Reserves as of January 1, 1980, Copper, Nickel, Lead, Zinc, Molybdenum, Silver, Gold;** Energy, Mines and Resources Canada, 1980.

[3] **MR 170, A Summary View of Canadian Reserves and Additional Resources of Iron Ore,** Energy, Mines and Resources Canada, 1977.

(E) Uranium

	"Reasonably Assured"	
	Measured	Indicated
	(tonnes U)	
Mineable at uranium prices of:		
$Cdn.130/kg U or less	73 000	157 000
$130 to $200/kg U:	4 000	25 000

The tonnages refer to uranium contained in mineable ore. Unless otherwise specified, uranium "reserves" in Canada refer to the tonnages mineable at uranium prices of $130/kg U or less[4].

(F) Coal

- **Bituminous**	1 607 million tonnes (of which 1 263 million tonnes could be used for metallurgical purposes)
- **Sub-bituminous**	2 182 million tonnes
- **Lignitic**	2 117 million tonnes

These represent tonnages that could be recovered as run-of-mine coal, with current technology and at current market prices, from measured and indicated coal in deposits that are legally open to mining. For the purpose of making these estimates, it was assumed that coal sales would cover the costs of any required infrastructure not already in place[5].

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[4] **EP80-3, Uranium in Canada: 1979 Assessment of Supply and Requirements,** Energy, Mines and Resources Canada, 1980.

[5] **ER 79-9, Coal Resources and Reserves of Canada,** Energy, Mines and Resources Canada, 1979.

Aluminum

D. PEARSON AND G.E. WITTUR

The Canadian and international aluminum markets were relatively favorable in 1980 as a whole, being strong during the first half but weakening in the second half. In Canada, aluminum smelters operated at, and in some cases above, their rated capacities. Both of the existing primary producers reported programs to improve and expand their production facilities, while several foreign aluminum companies were investigating Canadian locations for prospective new smelters. Internationally, numerous new bauxite, alumina and aluminum production facilities were under construction or announced, which should assure adequate capacity to meet anticipated demands until the mid-1980s.

CANADA

Primary aluminum is produced in Canada by two companies: Aluminum Company of Canada, Limited (Alcan), a subsidiary of Alcan Aluminium Limited of Montreal, and Canadian Reynolds Metals Company, Limited, a subsidiary of Reynolds Metals Company of Richmond, Virginia. Their combined production rose 24 per cent from that in 1979, when strikes at Alcan's Quebec smelters had reduced production (Table 1).

Canada's bauxite imports rose by 63 per cent and alumina imports rose by 3 per cent in 1980, while primary aluminum exports were 42 per cent higher (Table 1). Brazil became one of Canada's leading sources of bauxite with the completion of a large new mining operation owned partly by Alcan. Consumption of primary aluminum in Canada declined slightly in 1980, to 384 854 t (Table 2).

Alcan operates five smelters in Quebec - at Jonquière, Grande Baie, Isle Maligne, Shawinigan and Beauharnois - and one in British Columbia at Kitimat, with a combined annual capacity of 961 000 t as of year-end (Table 4). An alumina refinery at Jonquière, with a capacity of 1 225 000 tonnes per year (tpy), supplies alumina to Alcan's Quebec smelters while the Kitimat smelter uses imported alumina. The Canadian Reynolds smelter at Baie Comeau has a capacity of 158 760 tpy of aluminum using imported alumina.

Alcan is updating its alumina refinery at Jonquière by the installation of energy-efficient fluid flash calciners and modernization of the alumina precipitation circuit. The fluoride plant at the same location is to be replaced with a new 30 000 tpy plant at a cost of about $60 million.

Alcan Canada Products Limited has installed a new 84-inch-wide, direct chill-caster at its Saguenay Works which will permit the rolling of hard alloy re-roll stock. This is the first of a two-phase program to expand casting capacity at the Arvida smelter. Good progress was made on the new smelter at Grand Baie, Quebec. The first of three 57 000 tpy potlines was completed in 1980 and work was progressing on the other two potlines. In British Columbia, plans to increase capacity of the Kemano generating station met opposition from the provincial and federal governments and local environmental groups. The company will continue to examine the situation to determine the conditions which will satisfy all parties in order to complete the project. Installation of Sumitomo Corporation technology on half a potline was completed and

TABLE 1. CANADA, ALUMINUM PRODUCTION AND TRADE, 1979 AND 1980

	1979		1980P	
	(tonnes)	($000)	(tonnes)	($000)
Primary Production	860 286	..	1 068 198	..
Imports				
Bauxite ore				
Brazil	320 039	7,458	1 471 566	40,771
Guinea	841 253	20,937	1 505 902	39,612
Guyana	648 806	13,189	346 874	9,389
Surinam	87 436	10,050	62 652	7,321
Jamaica	–	–	28 768	6,686
United States	31 389	3,813	34 970	4,840
Australia	53 057	5,083	43 010	2,922
Other countries	167 656	3,204	10 685	189
Total	2 149 636	63,734	3 504 427	111,730
Alumina				
Australia	468 357	79,784	374 065	76,882
United States	154 755	40,141	276 894	72,814
Japan	55 710	8,436	171 497	33,953
Jamaica	178 204	32,555	128 668	32,191
West Germany	95 442	23,539	32 956	9,039
Other countries	60	41	–	–
Total	952 528	184,496	984 080	224,879
Aluminum and aluminum alloy scrap	30 681	13,837	30 724	19,003
Aluminum paste and aluminum powder	5 902	10,400	4 054	8,523
Pigs, ingots, shot, slabs, billets, blooms and extruded wire bars	23 985	43,139	9 907	18,554
Castings	986	6,023	1 398	11,288
Forgings	1 110	11,953	1 421	17,245
Bars and rods, nes	17 030	35,717	11 008	24,606
Plates	13 564	35,396	12 869	51,277
Sheet and strip up to .025 inch thick	20 518	46,564	21 734	50,489
Sheet and strip over .025 inch up to .051 inch thick	12 252	33,044	8 475	24,410
Sheet and strip over .051 inch up to .125 inch thick	28 151	57,834	20 964	48,722
Sheet over .125 inch thick	35 892	68,554	28 760	61,385
Foil or leaf	439	1,399	838	2,828
Converted aluminum foil	..	16,052	..	18,219
Structural shapes	2 990	16,110	2 173	10,654
Pipe and tubing	1 452	5,601	1 022	4,882
Wire and cable, not insulated	3 890	9,712	3 409	8,957
Aluminum and aluminum alloy fabricated materials, nes	..	59,999	..	79,864
Total aluminum imports	..	471,334	..	460,906
Exports				
Pigs, ingots, shot, slabs, billets, blooms and extruded wire bars				
United States	333 008	479,900	438 074	766,043
Japan	72 482	110,434	125 011	203,961
Netherlands	12 360	18,767	36 470	65,594
People's Republic of China	33 956	49,084	29 995	59,228
Thailand	13 923	21,519	19 779	42,187
Brazil	11 893	20,040	12 528	26,540

TABLE 1. (cont'd)

	1979		1980P	
	(tonnes)	($000)	(tonnes)	($000)
Exports (cont'd)				
South Korea	7 916	11,562	14 431	25,495
Hong Kong	7 948	12,170	11 622	23,369
Portugal	10 945	17,378	10 546	22,522
Italy	15	29	12 830	22,316
Malaysia	5 858	9,561	8 236	17,756
Other countries	41 392	66,818	65 216	132,576
Total	551 696	817,262	784 738	1,407,587
Castings and forgings				
United States	3 814	22,485	4 122	29,833
United Kingdom	43	2,956	49	3,400
West Germany	96	3,154	79	3,212
France	8	558	31	1,167
Other countries	40	1,074	67	1,631
Total	4 001	30,227	4 348	39,243
Bars, rods, plates, sheets and circles				
United States	12 232	28,422	11 989	28,018
Netherlands	223	640	782	2,486
Venezuela	734	1,892	572	1,627
Indonesia	-	-	428	1,151
Dominican Republic	259	606	439	973
Guyana	1	3	278	766
United Kingdom	53	174	263	750
Trinidad-Tobago	492	1,173	270	726
Japan	69	200	302	586
Ecuador	29	52	158	565
Other countries	2 219	4,483	1 286	3,671
Total	16 311	37,645	16 767	41,319
Foil				
Chile	-	-	76	290
West Germany	-	-	99	262
Colombia	-	-	35	120
Lebanon	-	-	34	93
South Africa	-	-	31	77
Other countries	247	677	122	267
Total	247	677	397	1,109
Fabricated materials, nes				
United States	10 840	21,040	10 615	26,430
Colombia	1	2	4 330	7,238
United Kingdom	389	1,110	381	1,482
Italy	19	17	289	891
Lebanon	-	-	259	859
Morocco	2 004	2,811	369	747
Japan	20	21	376	703
Other countries	2 186	6,710	1 517	4,746
Total	15 459	31,711	18 136	43,096

TABLE 1. (cont'd)

	1979		1980P	
	(tonnes)	($000)	(tonnes)	($000)
Exports (cont'd)				
Ores and concentrates				
United States	22 287	6,619	33 254	10,482
Italy	579	203	2 127	908
United Kingdom	861	313	1 784	762
France	765	337	704	361
Brazil	122	108	326	160
Venezuela	-	-	299	138
Other countries	860	418	1 014	468
Total	25 474	7,998	39 508	13,279
Scrap				
United States	49 750	50,217	49 342	62,782
Japan	14 216	18,296	22 444	35,392
West Germany	1 569	959	1 724	2,251
France	881	861	1 149	1,115
Italy	1 239	935	888	997
Spain	1 071	653	1 058	891
Netherlands	68	48	347	470
Belgium-Luxembourg	75	89	303	463
Other countries	1 469	1,100	875	1,024
Total	70 338	73,158	78 130	105,385
Total aluminum exports	..	998,678	..	1,651,018

Sources: Statistics Canada; Energy, Mines and Resources, Canada.
P Preliminary; - Nil; .. Not available; nes Not elsewhere specified.

testing commenced; it is expected to produce energy savings and improve environmental conditions. There was a two-day strike by Kitimat smelter workers followed by the signing in October of a 30 month contract. The company is actively studying future smelter sites in Quebec and Manitoba and a feasibility study is under way for a plant in the latter province.

Canadian Reynolds Metals Company plans to modernize and expand its smelter at Baie Comeau and is negotiating with the Quebec government for additional electric power. Annual capacity could be increased to about 272 000 t by 1984. The company will employ the Sumitomo smelting technique. Costs are expected to be about $575 million.

During the year, interest was shown in a possible smelter development in Labrador which would use electric power from the Churchill River. No decisions had been made by year-end. Pechiney Ugine Kuhlmann, a French aluminum producer, has taken an option on land near Beçancour, on the south bank of the St. Lawrence river in Quebec, and a feasibility study for a 230 000 tpy smelter is being undertaken.

WORLD REVIEW

Estimated world production of bauxite rose 3.6 per cent in 1980 (Table 5) while non-communist world production of alumina rose 4.2 per cent (Table 6). Australia was by far the largest bauxite producer, followed by Jamaica and Guinea.

World primary aluminum production in 1980 is estimated to have risen by about 5.3 per cent (Table 7). Reported world consumption fell by 4 per cent, however, and stocks rose significantly. While data are not available on total world stocks, producers' stocks in non-communist countries rose by 38 per cent in 1980 and totalled 2.1 million t at year-end.

In the United States, which is by far the world's largest producer and consumer of primary aluminum, apparent consumption was the lowest since 1977. Production rose slightly but was restricted by electrical power shortages in the Pacific northwest that caused closures of some potlines for periods of a month or so. Later in the year, in order to balance inventories, less-efficient potlines were closed. Most companies are

TABLE 2. CANADA, CONSUMPTION OF ALUMINUM AT FIRST PROCESSING STAGE, 1977-80

	1977	1978	1979	1980P
	(tonnes)			
Castings				
Sand	1 277	1 496	1 792	1 668
Permanent mould	17 711	14 483	11 680	8 577
Die	20 538	23 234	26 293	20 427
Other	65	65	148	-
Total	39 591	39 278	39 913	30 672
Wrought products				
Extrusions, including tubing	84 019	87 625	99 438	99 437
Sheet, plate, coil and foil	134 278	159 720	166 049	160 564
Other wrought products (including rod, forgings and slugs)	61 318	81 833	80 910	82 986
Total	279 615	329 178	346 397	342 987
Other uses				
Destructive uses (deoxidizer), non-aluminum base alloys, powder and paste	13 187	11 834	12 739	11 195
Total consumed	332 393	380 290	399 049	384 854
Secondary aluminum[1]	51 260	44 627	35 527	37 117

	Metal entering plant		On hand December 31	
	1979	1980	1979	1980
Primary aluminum ingot and alloys	344 215	365 144	92 794	107 986
Secondary aluminum	49 402	27 655	3 832	4 459
Scrap originating outside plant	47 367	47 783	17 052	19 844
Total	440 984	440 582	113 678	132 289

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Aluminum metal used in the production of secondary aluminum.
P Preliminary; - Nil.

attempting to reduce power usage by various methods. Alumax, Inc. opened the first "greenfield" smelter in the United States since 1973; the plant at Mt. Holly, South Carolina has a capacity of about 179 000 tpy and cost $US 350 million. Ultimate capacity of this smelter will be about 377 400 tpy, which will make it the fourth largest aluminum smelter in the United States.

Australia is already the world's largest producer of bauxite and alumina, supplying 31 per cent of world bauxite production and processing about 75 per cent of that production into alumina. Bauxite and alumina production fell slightly from that in 1979 due to a strike at Pinjarra. Australia exported about 6.7 million t of alumina in 1980, of which Canada received 374 065 t from the Queensland Alumina Ltd. refinery owned 21.4 per cent by Alcan. Studies are under way to expand the Queensland plant to supply alumina for a proposed smelter in Queensland and the expansion of Alcan's Kurri Kurri smelter in New South Wales. Cost is expected to be in excess of $200 million. It is projected that by the mid-1980s, based on current proposals, total alumina production in Australia will increase to between 9.3 and 9.7 million t.

Currently in Australia, there are three primary aluminum smelters with a combined annual capacity of 345 000 t and which produced an estimated 303 500 t of aluminum in 1980. During the year several corporations submitted proposals for smelter projects to various states. Should all of these be approved, Australia's aluminum capacity could increase to about 1.55 million tpy by 1985 and to over 2 million tpy beyond 1985 when the smelters are developed to full capacity. These plans will require a total investment of about $6 billion for bauxite mines, alumina refineries and aluminum smelters. One of the largest projects, the Tomago Aluminum Smelter complex to be built at a cost of $A 600 million in the Hunter Valley of New South Wales, will produce 220 000 tpy of aluminum. This project is expected to take seven years to complete and will eventually employ 5,000. Alcan plans to increase capacity of its Kurri Kurri smelter by 45 000 t to 130 000 tpy, and is conducting a detailed feasibility and engineering study for a 100 000 tpy smelter in Queensland.

Brazil is becoming a major bauxite producer and, with the very large hydroelectric power potential of the Amazon basin, will become an important producer of aluminum in the 1980s. Reported bauxite production was 4.15 million t in 1980 and is expected to reach 15 million tpy during the 1980s. The Trombetas bauxite project of Minerção Rio do Norte SA in the northern state of Para exported 2.8 million t in 1980, its first full year of operation, of which 1.2 million t was delivered to Canada. Alcan owns 19 per cent of this operation. A study is now being made to determine if an increase in bauxite capacity to 10 million tpy from the present 3.35 million tpy is justified. A number of expansion plans for aluminum smelters were announced by various companies during the year. If all are built, aluminum production could rise to 328 000 tpy at a cost of about $US 350 million. A smelter being built by Valesul Aluminio SA at Santa Cruz to produce 86 000 tpy is expected to begin production in 1982 and to be fully completed in 1986 at a cost of $US 358 million.

Alcoa Aluminio S.A. began site preparations for an alumina-aluminum complex near Sao Luis in the Brazilian State of Moranhao. Initial capacity of the alumina refinery, to come on stream by the end of 1983, will be 500 000 tpy. Smelter capacity will be 100 000 tpy beginning in 1984. Cost of the project is expected to be about $1.3 billion. Bauxite for the project will come from the Trombetas operation. If warranted, capacity of the refinery and smelter can be increased to 3 million tpy and 500 000 tpy, respectively.

TABLE 3. CANADA, PRIMARY ALUMINUM PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975-80

	Production	Imports	Exports	Consumption[1]
		(tonnes)		
1970	962 541	12 179	761 671	250 150
1975	878 056	18 302	512 050	293 280
1976	628 049	22 556	510 751	322 206
1977	973 524	20 788	655 353	332 393
1978	1 048 469	11 481	863 320[r]	380 290
1979	860 286	23 985	551 696	399 049
1980P	1 068 198	9 907	784 738	384 854

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Excluding aluminum metal used in the production of secondary aluminum.

P Preliminary; [r] Revised.

Demand for aluminum in Brazil has been growing at a rate of 13 per cent a year. Eventually most of the Brazilian aluminum production will be consumed internally.

The Japanese aluminum industry continued to have problems resulting from higher energy costs, excessive aluminum imports and a decline in domestic consumption. The Ministry of International Trade and Industry (MITI) ordered a restructuring of the industry whereby annual aluminum capacity is to be reduced from 1.48 million to just under 1 million t. Nevertheless production in 1980, at 1.09 million t, was 8 per cent higher than 1979. Japanese demand for primary aluminum was strong in the first half of the year but dropped off in the second half. Total demand fell 6 per cent from that in 1979. Imports of primary ingot reached a record 910 000 t, of which 309 700 t were supplied by the United States. Canada supplied 125 011 t of ingot and 22 444 t of scrap. Japanese producer stocks of aluminum rose in 1980 to their highest level in two and a half years and consequently, the Japan Light Metal Stockpile Association began negotiations with MITI to increase government stockpiling.

TABLE 4. CANADA, ALUMINUM SMELTER CAPACITY

(as of January 1, 1981)

	Annual tonnes
Aluminum Company of Canada Limited	
Quebec	
Grande Baie	57 000
Jonquière	432 000
Isle-Maligne	73 000
Shawinigan	84 000
Beauharnois	47 000
British Columbia	
Kitimat	268 000
Total Alcan capacity	961 000
Canadian Reynolds Metals Company, Limited	
Quebec	
Baie Comeau	158 760
Total Canadian capacity	1 119 760

Source: Compiled from company reports by Energy, Mines and Resources Canada.

TABLE 5. ESTIMATED WORLD PRODUCTION OF BAUXITE 1979 AND 1980

	1979	1980
	(million tonnes)	
Australia	27.59	27.18
Jamaica	11.51	12.06
Guinea	12.20	11.76
Surinam	4.74	4.90
Brazil	1.64	4.15
Greece	2.87	3.29
Guyana	3.35	3.05
France	1.97	1.89
India	1.95	1.74
United States	1.82	1.56
Other Non-communist	3.57	4.60
Communist countries[1]	14.70	14.89
World total	87.91	91.07

Source: World Bureau of Metal Statistics.
[1] Includes Yugoslavia.

The Nigata smelter, owned 50 per cent by Alcan and 50 per cent by Japanese interests, was closed in 1979 because of high energy costs and the equipment was sold in 1980 to the South African aluminum company, Alusaf (Pty.) Ltd.

Japanese companies are already heavily involved in various projects in Australia and Brazil. With the continued increase in energy prices the country's policy is to obtain a third of its aluminum requirements from offshore projects in which Japanese companies have an interest.

India had a shortfall of about 160 000 t of aluminum in 1980, due mostly to an inadequate power supply for its smelter and refineries. The shortage of aluminum was overcome by purchases on a spot and contract basis from various sources and negotiations were continuing to ensure future aluminum supplies to cover an estimated consumption of 355 000 tpy. Hindustan Aluminum Corp. Ltd. (Hindalco) plans to increase its smelter capacity from 190 000 t to 300 000 t, and two new alumina refineries, each of 800 000 tpy, are planned. Pechiney Ugine Kuhlmann will build one refinery in Orissa state and the second will be built with Russian help in Andhra Pradesh state.

In Western Europe, demand for aluminum and aluminum products was at a high level during the first half of 1980. Production kept pace with the optimism of the marketplace, rising 4.6 per cent. Production has been increasing at an average annual rate of 3.5 per cent since 1975. Consumption declined slightly in 1980, however. Aluminum stocks on the London Metal Exchange increased to 70 575 t by year-end, while inventories at smelters and fabrication plants decreased during the first five months to 429 000 t and then rose substantially to 669 000 t by December.

In Spain, the San Ciprian smelter, owned 55 per cent by Empresa Nacional del Aluminio SA (Endasa), began production in 1979 and reached its full operating capacity of 180 000 tpy in mid-1980. The related alumina plant came on stream in September and is expected to reach its full annual capacity of 800 000 tpy in 1981. Alcan owns 42 per cent of Endasa. Spanish aluminum production from five smelters reached a record 386 492 t in 1980. Spain's plans are to achieve self-sufficiency in both alumina and aluminum production. When the proposed expansions are completed, Spain will rank as the third-largest producer of aluminum in Europe at about 400 000 tpy.

TABLE 6. ESTIMATED NON-COMMUNIST WORLD PRODUCTION OF ALUMINA, 1979 AND 1980

	1979	1980
	(million tonnes)	
Europe	4.20	4.51
Africa	0.66	0.71
Asia	2.45	2.95
North America	7.35	8.09
South America	4.00	4.60
Australasia	7.39	7.25
Total	26.03	28.11
of which non-metallic uses	2.36	2.32

Source: World Bureau of Metal Statistics (based on data published by International Primary Aluminum Institute and others).

Norsk Hydro A/S Karmoey Fabrikker announced plans to increase the capacity of its Karmoey Fabrikker smelter to 160 000 tpy from 110 000 t. Production from Norway's nine primary aluminum smelters in 1980 was 661 700 t and it is planned to increase capacity to about 800 000 tpy by 1985 if power costs and other factors remain more or less the same. However, there has been speculation that the Norwegian government is considering a large increase in power rates, which could cause cancellation of expansion plans.

Construction at Ireland's Aughinish alumina plant, in which Alcan has a 40 per cent interest, has been plagued by strikes and mounting costs due to interest rate escalation, inflation and exchange variations. Estimated cost of the 800 000 tpy plant has soared 30 per cent to about $US 750 million and start-up is now projected for 1983. Bauxite will be imported from Guinea.

The Gulf countries of the Middle East are planning a massive expansion of their aluminum industry, based on natural gas-fired electric power. As many as five smelters and an alumina refinery are planned. Aluminum capacity would rise to between 0.75 and 1 million tpy from the current 270 000 tpy. Also included in the plans is a rolling mill to produce sheet and strip at an annual rate of 40 000 t.

A number of other smelter projects are being considered in the Philippines, Mexico and Argentina which could increase world production of aluminum by more than 200 000 tpy.

TABLE 7. WORLD PRIMARY ALUMINUM PRODUCTION AND CONSUMPTION, 1979 AND 1980

	Production		Consumption	
	1979	1980P	1979	1980P
	(000 tonnes)			
United States	4 556.8	4 581.3	5 017.7	4 473.0
Europe[1]	3 592.5	3 762.3	3 882.9	3 855.1
Japan	1 010.4	1 091.5	1 803.4	1 636.8
Canada	860.3	1 068.2	399.0	384.9
Australia and New Zealand	423.7	459.7	240.3	242.7
Asia (excluding Japan and People's Republic of China)	454.6	464.0	644.9	659.6
Africa	400.7	437.3	119.5	171.2
America (excluding United States and Canada)	674.3	820.5	539.0	604.9
Sub-total	11 973.3	12 684.8	12 646.7	12 028.2
Central economy countries	3 192.4	3 287.9	3 375.6	3 310.0
Total	15 165.7	15 972.7	16 022.3	15 338.2

Sources: World Bureau of Metal Statistics; for Canada, Energy, Mines and Resources Canada; for United States, United States Bureau of Mines.
[1] Excludes Yugoslavia.
P Preliminary.

PRICES AND STOCKS

The U.S. market price for primary aluminum ingot rose from 78 cents a pound in January to a high of 92 cents on February 29, but then declined before firming at about 68 cents. The LME cash price averaged 80.5 cents a pound for the year.

Producers' stocks of primary metal, as reported by the International Primary Aluminium Institute, were 1 469 000 t in January. This level dropped marginally until April but then increased to 2 091 000 t in December.

OUTLOOK

The aluminum industry, which experienced annual growth rates of 8 to 9 per cent during the 1950s and 1960s, was one of the most profoundly affected by rising energy prices in the 1970s due to its high energy consumption. This has led to pronounced shifts in industry structure and location, particularly in smelting where electrical power costs are a critical factor. In this regard, Canada is in a relatively good competitive position, along with a few other countries.

With a number of projects coming on stream in the immediate future, the additional capacity is expected to satisfy the anticipated demand until at least the mid-1980s. It has been estimated that by 1990 an additional 6.8 million tpy of primary aluminum capacity will be needed. Additional alumina and bauxite facilities will also be necessary. For the most part, the future development will take place in countries such as Australia and Brazil in which the bauxite deposits are enormous and energy costs relatively low as compared with other industrial countries.

Future world demand for aluminum is expected to grow more slowly, possibly in the range of 3 to 5 per cent annually. Packaging and electrical power transmission will account for an increasing share of aluminum consumption, while use in construction will grow more slowly due to competition from other materials. Predictions for greater use of aluminum in automobiles are not likely to be realized in the immediate future, although overall consumption prospects in transportation equipment appear favorable. Because of the high energy requirements to produce primary aluminum, there is a tendency to recycle more metal and it is expected that this trend will continue.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
32910-1	Bauxite	free	free	free	free
35301-1	Aluminum pigs, ingots, blocks, notch bars, slabs, billets, blooms and wire bars, per pound	free	.9¢	5¢	na
35302-1	Aluminum bars, rods, plates, sheets, strips, circles, squares, discs and rectangles	free	2.4%	7.5¢ per pound	free
35303-1	Aluminum channels, beams, tees and other rolled, drawn or extruded sections and shapes	free	11.9%	30%	free
35305-1	Aluminum pipes and tubes	free	11.9%	30%	free
92820-1	Aluminum oxide and hydroxide; artificial corundum (this tariff includes alumina)	free	free	free	free

MFN Reductions under GATT (effective January 1 of year given)

	1980	1981	1982	1983	1984	1985	1986	1987
32910-1	Remains free							
35301-1	.9¢	.8¢	.6¢	.5¢	.4¢	.3¢	.1¢	free
35302-1	2.4%	2.3%	2.3%	2.3%	2.2%	2.2%	2.1%	2.1%
35303-1	11.9%	11.4%	10.8%	10.3%	9.7%	9.1%	8.6%	8.0%
35305-1	11.9%	11.4%	10.8%	10.3%	9.7%	9.1%	8.6%	8.0%
92820-1	Remains free							

UNITED STATES

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
417.12	Aluminum compounds: hydroxide and oxide (alumina)	Remains free							
601.06	Bauxite	Remains free							
618.01	Unwrought aluminum in coils, uniform cross section not greater than 0.375 inch, per pound	3.1%	3.1%	3.0%	2.9%	2.8%	2.8%	2.7%	2.6%
618.02	Other unwrought aluminum, excluding alloys, per pound	0.8¢	0.7¢	0.6¢	0.5¢	0.3¢	0.2¢	0.1¢	free
618.04	Aluminum silicon, per pound	2.4%	2.4%	2.4%	2.3%	2.3%	2.2%	2.2%	2.1%
618.06	Other aluminum alloys, per pound	0.8¢	0.7¢	0.6¢	0.5¢	0.3¢	0.2¢	0.1%	free
618.10	Aluminum waste and scrap, per pound[1]	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%

Sources: The Customs Tariff and Commodities Index Revenue Canada; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa; Tariff Schedules of the United States Annotated 1980, USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241.

[1] Duty on waste and scrap temporarily suspended.

na Item does not qualify under the General Preferential Tariff.

Antimony

J.J. HOGAN

Antimony produced in Canada in 1980 was obtained from one antimony mine and was also recovered as a byproduct of lead smelting operations that treat lead concentrates containing antimony. The value of antimony contained in ores and concentrates produced in 1980 was $6,014,000 compared with $7,432,296 in 1979. The value of the antimony content of primary antimonial-lead alloy produced in 1980 was $489,000, substantially below the revised value of $917,642 in 1979. Sharply lower demand for antimonial-lead because of changes in the technology of lead-acid batteries was responsible for the lower output.

Imports of antimony oxide in 1980 totalled 944 000 kilograms (kg) of which the United Kingdom supplied 59.2 per cent and the United States 33.2 per cent.

DOMESTIC SOURCES AND OCCURRENCES

Consolidated Durham Mines & Resources Limited operates Canada's only antimony mine at its Lake George property near Fredericton, New Brunswick. During the fiscal year ending June 30, 1980, the concentrator, rated at a capacity of 360 tpd of ore, treated 90 294 t of ore averaging 3.09 per cent antimony to produce 3 463 t of concentrate averaging 66.86 per cent antimony. In fiscal 1979, the concentrator treated 100 168 t of ore, averaging 3.58 per cent antimony to produce 4 337 t of concentrate, averaging 65.67 per cent antimony. The concentrates were of premium quality and were exported to the United States and western Europe. Presently developed ore reserves are limited and are expected to be depleted early in 1981. The concentrator will close but an exploration program will be continued. A deep diamond drill program has outlined a potential new orebody. Detailed drilling is under way to further assess the results of the initial drilling.

Production began in September 1980 at the Sam Goosly silver-copper property, which also contains antimony and arsenic, of Equity Silver Mines Limited, 37 km south of Houston in central British Columbia. Placer Development Limited holds a 70 per cent interest in Equity Silver and is manager of the operation. Designed capacity of the concentrator is 4 500 tpd of ore. Estimated cost of the project is $129 million, a substantial increase from the original estimate because of the need to redesign the leaching section of the plant. The leach plant, which will remove the impurities contained in the concentrates, is expected to be in operation in the latter part of 1981. The company estimates that the annual antimony output from the leaching operation will be about 1 700 tpy, an appreciable addition to Canada's antimony production. The property is essentially a silver mine and will produce an estimated 177 tpy of silver and 6 400 t of copper.

Cominco Ltd., which operates a lead smelter and refinery at Trail, British Columbia, is the main producer of primary antimonial-lead in Canada. It can produce

TABLE 1. CANADA, ANTIMONY PRODUCTION, IMPORTS AND CONSUMPTION, 1979 AND 1980

	1979		1980P	
	(kilograms)	($)	(kilograms)	($)
Production				
Antimonial lead alloy	177 047	917,642	93 000	489,000
Antimony in ores and concentrates	..	7,432,296	..	6,014,000
Total	..	8,349,938	..	6,503,000
Imports				
Antimony oxide				
United Kingdom	645 870	2,637,000	559 000	2,583,000
United States	68 901	258,000	313 000	1,295,000
Belgium-Luxembourg	69 490	256,000	52 000	206,000
France	9 979	41,000	20 000	78,000
Total	794 240	3,192,000	944 000	4,162,000

	1979		1980	
	Antimony Metal	Antimonial lead alloy[1]	Antimony Metal	Antimonial lead alloy[1]
	(kilograms)			
Consumption[2]				
Antimony used for, or in the production of:				
Antimonial lead	217 937	...		
Babbit	19 487	8 636		
Batteries	..	1 189 587		
Solder	14 500	..		
Type metal	..	..		
Other commodities	87 814	..		
Total	351 627	1 316 938	247 762	..
Held by consumers on December 31[2]	41 764	183 075	..	..

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Antimony content of primary and secondary antimonial lead alloys. [2] Available data, as reported by consumers.
P Preliminary; .. Not available; ... Not applicable.

antimonial-lead with an antimony content ranging up to 23 per cent, depending on customer requirements. Antimony contained in antimonial-lead alloy produced by Cominco in 1980 was reported to be 93 t compared with 177 t in 1979. Brunswick Mining and Smelting Corporation Limited, which operates a lead plant at Belledune, New Brunswick, has the facilities to produce antimonial-lead but did not do so in 1980. Secondary smelters recover antimonial-lead from scrap metal but no recent statistical data are available concerning this production.

Most of the antimonial-lead produced at Trail is a byproduct of lead concentrates obtained from Cominco's Sullivan mine at Kimberley, British Columbia. Other sources

TABLE 2. CANADA, CONSUMPTION AND CONSUMERS' STOCKS OF ANTIMONY[1], 1970, 1975-80

	Consumption		On hand at end of year	
	Antimony Metal	Antimonial lead alloy[2]	Antimony Metal	Antimonial lead alloy[2]
	(kilograms)			
1970	518 007	635 212	131 501	91 563
1975	454 164	723 155	116 760	170 478
1976	437 998	1 038 234	30 338	224 664
1977	370 867	1 204 416	27 932	132 262
1978	347 906	1 000 732	101 814	91 049
1979	351 627	1 316 938	41 764	183 075
1980	247 762	..	..	..

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Available data, as reported by consumers. [2] Antimony content of primary and secondary antimonial lead alloys.

.. Not available.

are lead-silver ores and concentrates shipped to Trail from other Cominco mines and from custom shippers. The lead bullion produced from the smelting of these ores and concentrates contains about 1 per cent antimony, which is recovered in anode residues from the electrolytic refining of the lead bullion, and in furnace drosses. These residues and drosses are treated to yield antimonial-lead alloy, to which refined lead may be added to produce marketable products of the required grade.

WORLD REVIEW

Increasing use of the lead-calcium automotive battery and the low antimonial-lead battery has reduced the demand for the standard antimonial-lead battery. However, any resulting decrease in the demand for antimony could be offset somewhat by growth in other types of batteries with high antimony content, such as batteries used in industrial traction equipment, and by increased consumption of antimony oxide as a flame retardant.

World mine production of antimony in 1980 was estimated by the American Bureau of Metal Statistics to be 64 853 t, compared with 62 779 t in 1979.

The world's major primary antimony producers in decreasing order of output in 1980, as shown in Table 3, were Bolivia, Republic of South Africa, China and the U.S.S.R. In 1980, these four countries accounted for over 69 per cent of the world total. Smaller producers were Thailand, Mexico, Canada, Morocco, Turkey, Australia and Yugoslavia.

Consolidated Murchison Limited operates the world's largest antimony mine, near Gravelotte in northern Transvaal, Republic of South Africa. The company processed 512 320 t of ore averaging 2.70 per cent antimony in 1980 compared with 534 500 t, averaging 2.60 per cent in 1979. Improved mining techniques were responsible for the higher grade of ore mined in 1980. Antimony concentrates and cobbed ore production in 1980 was 22 372 t grading 58.43 per cent, compared with 20 066 t grading 57.88 per cent in 1979. Mill recovery improved from 82.6 per cent in 1979 to 87.4 per cent in 1980. Working costs per t milled increased by 24 per cent because of inflation and reduced tonnage, but the cost per t of antimony produced increased by only 7 per cent because of higher grades and mill recovery. Sales of antimony concentrates and cobs declined drastically in 1980 to 12 717 t, compared

TABLE 3. WORLD MINE PRODUCTION OF ANTIMONY, 1978-80

	1978	1979	1980e
		(tonnes)	
Bolivia	12 672	13 019	15 470
Republic of South Africa	9 094	11 755	11 420
People's Republic of Chinae	12 701	15 422	9 980
U.S.S.R.e	7 893	8 165	8 170
Thailand	2 873	2 903	2 850
Mexico[1]	2 457	2 449	2 450
Canada[2]	2 994	2 994	2 140
Morocco	2 211	2 087	2 000
Turkey	2 368	2 449	1 810
Australia[3]	1 514	2 087	1 560
Yugoslavia	2 758	2 812	1 540
Peru	895	898	770
Guatemala	230	227	730
Italy	931	907	710
United States	724	655	310
Czechoslovakiae	299	299	300
Other countries	2 814	2 885	2 640
Total	65 428	72 013	64 850

Sources: The United States Department of the Interior, U.S. Bureau of Mines, Minerals Yearbook Antimony Preprint, 1978-79 for 1978 and 1979; Non-Ferrous Metal Data 1980, American Bureau of Metal Statistics Inc. for 1980.

[1] Antimony content of ores for export plus antimony content of antimonial lead and other smelter products produced. [2] Estimated on the basis of value of production. [3] Antimony content of antimony ore and concentrates, lead concentrates, and lead and zinc middlings.
e Estimated.

TABLE 4. INDUSTRIAL CONSUMPTION OF PRIMARY ANTIMONY IN THE UNITED STATES BY CLASS OF MATERIAL PRODUCED, 1978-80

	1978	1979	1980P
	(tonnes, antimony content)		
Metal Products			
Ammunition	121	229	329
Antimonial lead	2 569	1 179	376
Bearing metal and bearings	253	213	141
Cable covering	19	15	28
Castings	14	13	1
Collapsible tubes and foil	15	22	14
Sheet and pipe	35	33	23
Solder	187	181	41
Type metal	73	34	5
Other	103	90	33
Total	3 389	2 009	991
Nonmetal Products			
Ammunition primers	12	21	12
Fireworks	4	5	4
Flameproofing chemicals and compounds	5 311	5 518	3 000
Ceramics & glass	1 142	1 022	1 098
Pigments	372	362	306
Plastics	1 321	1 433	631
Rubber products	230	165	59
Other	150	127	13
Total	8 542	8 653	5 123
Total reported	11 931	10 662	6 114
Grand Total	11 931	10 662	9 685[1]

Source: U.S. Bureau of Mines, Mineral Industry Surveys.
[1] Estimated 100 per cent coverage based on reports from respondents that consumed 63 per cent of the total antimony in 1979.
P Preliminary.

with 22 473 t in 1979. Sales were normal in the first six months of the year but totalled only 1 678 t in the last six months. Because of the sharp decline in demand, the company lowered its monthly mill rate to 30 000 t by year-end. At this rate, production of concentrates and cobbed ore is expected to be about 14 000 t in 1981.

Most of the concentrate is treated at the nearby plant of Antimony Products, owned 30 per cent by Consolidated Murchison, for the production of crude antimony oxide for overseas customers. The remainder is exported to the United Kingdom, Europe and the United States. In 1980, Antimony Products completed the installation of the fifth and sixth kilns at its oxide plant and now has sufficient capacity to treat all of its concentrates.

Bolivia was the world's largest producer of antimony in 1980. Production is estimated at 15 465 t in 1980, an increase of about 18.8 per cent from 1979. The antimony smelter of Empresa Nacional de Fundiciones (ENAF) at Vinto operated well below its designed capacity of about 9 250 t because of reduced demand for antimony and antimony products. However, some antimony concentrates are exported to the United States, Europe and Japan.

The low antimony price led to the establishment of Comitê Bolivian de Productores de Antimonio, a Bolivian producer's group. The Bolivians hope to eventually make the new producer group an international organization. Its objectives would be to define trading policies, to establish an antimony pricing policy and to research and promote antimony uses.

China is one of the major world producers of antimony metal but production was lower in 1980 than in 1979 because of reduced demand. Most of the ore occurs in southwestern Hunan province and is mined primarily for its antimony content. Antimony recovered from polymetallic deposits is becoming an increasingly important source of the metal. China has large reserves and could produce at a higher rate but not at present prices.

In Yugoslavia, the Winogradi Antimony Mine, part of the Zajeca mine and metallurgical complex at Lozinca, is to be brought into production early in 1981. The mine is designed to produce about 1 900 tpy of antimony concentrate from the treatment of about 60 000 t of ore. The Zajeca Complex is the only producer of antimony in Yugoslavia. In 1980, production was about 6 200 t of concentrates.

N L Industries, Inc. of the United States sold its 49 per cent interst in the Mexican antimony mine of Cia Minera y Refinadora Mexicana SA to LIG Overseas Ltd. of London. LIG's interest will be handled by its subsidiary, Anzon America Inc. of New Jersey. The mine is a substantial supplier of ore to Anzon's Laredo, Texas oxide plant.

Consumption of primary antimony in the United States, the non-communist world's largest consumer, was estimated by the United States Bureau of Mines, at 10 196 t in 1980, about 15.7 per cent of the world's primary production, compared with 9 093 t in 1979. The United States depends on imports, mainly from Bolivia, Mexico and Canada for ore and concentrates, the People's Republic of China for antimony metal, and the Republic of South Africa and China for antimony oxide. South Africa was the largest overall U.S. supplier of antimony in 1979 with 5 306 t, followed by Bolivia and the People's Republic of China with 4 292 t and 2 213 t, respectively.

Production of antimony from secondary material is an important source of antimony. In 1980, United States production was 21 913 t, mostly from antimonial-lead. As antimonial lead for use in batteries is phased out, secondary recovery should decline.

In 1980 there were no sales of antimony by the United States General Services Administration (GSA) from the nation's strategic and critical material stockpile. The stockpile goal for antimony was revised to 32 659 t from 18 262 t in 1979. The surplus antimony in the stockpile, which now totals 4 290 t, requires congressional approval before sales can be made. The disposal policy for this surplus is under discussion in the United States Congress.

The antimony content of industrial stocks in the United States at the end of 1980 was 7 630 t.

USES

Antimony is used principally as an alloy and in the form of oxides. Sulphide forms are used to a lesser extent.

Antimony hardens and strengthens lead and inhibits chemical corrosion. These characteristics created a large use for the metal in antimonial-lead storage batteries. However, the introducton of the low antimonial-lead battery and the lead-calcium battery has drastically lowered its use in this application. Antimony's largest use, as antimony trioxide or trichloride, is as a fire retardant in products such as automotive upholstery, carpets and carpet underlays, as well as in plastics, insulation for electrical equipment and fibreglass boats.

The trioxide is also a glass-former and is sought for its ability to impart hardness and acid resistance to enamel coverings for bathtubs, sinks, toilet bowls and refrigerators. Sodium antimonate is used in the producton of high-quality glass and has a growing use in the manufacture of television screens. The pentasulphide (Sb_2S_5) is used as a vulcanizing agent by the rubber industry. Burning antimony sulphide creates a dense white smoke that is used in visual control, in sea markers and in visual signaling.

Antimonial lead alloys are also used for power transmission and communications equipment, type metal, solder, ammunition, chemical pumps and pipes, tank linings, roofing sheets and antifriction bearings. Antimony increases hardness, minimizes shrinkage, permits sharp definition and lowers the melting point of type metal. In antifriction bearings, antimony with tin forms hard tin-antimony crystals that increase bearing life.

Antimony is valuable for paint formulation because of its high hiding power and, along with various chemical compounds, it produces a wide range of pigments. High-purity metal is used in the production of indium-antimony and aluminum-antimony intermetallic alloys for semiconductors.

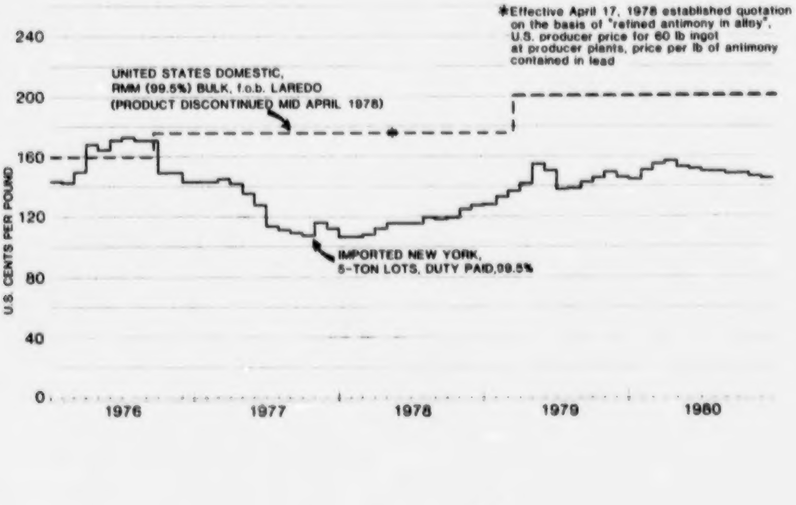
PRICES

The producer price for antimony contained in antimony lead alloy, in 60 pound ingots fob producer plants, as quoted in **Metals Week**, was constant for the year 1980 at a price of $US 2 per pound.

The New York dealer price for foreign metal remained comparatively stable in 1980. The opening price was $US 1.45-1.50 per pound. In early February it started an upward trend, reaching a high of $1.58-$1.65 in early April on increased demand from eastern European sources. This demand slackened in early May and the price drifted lower for the year, closing at $1.47 to $1.51.

The European free market metal price for 99.6 per cent antimony, cif Europe as quoted in **Metal Bulletin** opened the year 1980 at $US 3,200 to $3,260 per t. With minor fluctuations the antimony price for the year was in the range of $US 3,190 to $3,450 per t and closed at $US 3,190 to $3,250 per t.

ANTIMONY METAL PRICES



The price of antimony lump ore, as quoted in **Metal Bulletin,** was stable in 1980. The opening quote was $US 23 to 24.75 per short ton unit (20 pounds) but prices rose to $23.50 to $25 early in the year and remained at this level for the balance of the year.

Most United States producers quoted antimony trioxide at $US 1.80 per pound but the ASARCO Incorporated price was quoted at $1.50 per pound.

OUTLOOK

The general recession in the automotive and durable goods industries, especially in the latter part of 1980, curtailed the use of antimony in batteries, and flame retardant applications. In the United Kingdom, maintenance-free batteries are beginning to enter the market and will reduce demand for antimonial-lead in that market. No sharp upturn in antimony is expected in the short-term. Any increase in use in flame-retardant applications will be offset by reduced use of the metal in batteries.

In the short- to medium-term the supply of antimony will be more than adequate to meet demand. South Africa and Bolivia have curtailed output and if the need arises this cut-back could readily be reversed. China has large reserves of antimony and production could, if necessary, be increased to meet demands. No problems of supply are envisaged in the longer term.

TARIFFS

CANADA

Item No.		British Preferential	General Preferential	Most Favoured Nation	General
			%		
33000-1	Antimony or regulus of, not ground, pulverized or otherwise manufactured	free	free	free	free
33502-1	Antimony oxides	free	free	10.9	25

MFN Reductions under GATT (effective January 1 of year given)

Item No.	1980	1981	1982	1983	1984	1985	1986	1987
				%				
33502-1	10.9	9.4	7.8	6.3	4.7	3.1	1.6	free

UNITED STATES

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
					(¢ per pound)				
601.03	Antimony ore	Remains free							
632.02	Antimony metal unwrought etc.	0.9	0.8	0.6	0.5	0.4	0.3	0.1	free

European Economic Community: (MFN)

Item No.		1980	Base Rate	Concession Rate
		%	%	%
26.01	Antimony ore	free	free	free

TARIFFS (cont'd)

Item No.		1980 %	Base Rate %	Concession Rate %
European Economic Community (cont'd)				
81.04	1. Antimony wrought waste and scrap	free	free	free
	2. Unwrought waste and scrap	-	8	-
	Other	8	10	8

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Schedules of the United States Annotated 1980, USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 22, No. L342, 1979.

Asbestos

G.O. VAGT

Shipments of asbestos fibre in 1980 were lower than in 1979 and demand for all grades, particularly the shortest lengths, continued weak during the year. Capital expenditures for modernization programs and for greater environmental control are expected to continue to be relatively large during the next several years.

Adverse publicity associated with asbestos dust-related disease, linked mainly to in-plant working conditions that existed in the past, along with a trend in some countries to initiate strict new regulations governing the use of asbestos-based products, contributed to weaker sales.

Negotiations between the Quebec government and General Dynamics Corporation of St. Louis, Missouri, for the company's holdings in Asbestos Corporation Limited were unsuccessful and court action to resolve constitutional issues continued until March, 1981.

CANADIAN PRODUCTION (SHIPMENTS)

Asbestos fibre shipments in 1980 were 1 335 000 tonnes (t) valued at $641,737,000 compared with 1 492 719 t valued at $607,460,815 in 1979. Approximately 88 per cent of total production was from Quebec, 7 per cent from British Columbia and 5 per cent from Newfoundland.

Total production figures since 1977, inclusive, include the approximate quantities of fibre contained in concentrate produced in Ungava and shipped for final milling in West Germany; not included are relatively small quantities of serpentine filler produced by Hedman Mines Limited, Timmins, Ontario.

Weaker demand for asbestos resulted from several factors including recessionary conditions affecting the construction industry, high interest rates discouraging new plant investment at the manufacturing level, a progression to mature products in some markets and a shortage of foreign currency in less developed countries. Suspicion by some regulatory groups that health hazards may still be associated with the workplace, even with relatively strict in-plant and outside emission regulations, also contributed to weaker demand. A 12-week strike at Asbestos Corporation Limited and a 9-week strike at Bell Asbestos Mines, Ltd. lowered output during the first half of 1980. Industry layoffs during the second half of the year and extending into 1981 affected 530 employees in Quebec.

Private negotiations between the Quebec Crown Corporation, la Société nationale de l'amiante (SNA), established by Bill 70 in May 1978, and General Dynamics Corporation (GDC) of St. Louis, failed to establish a purchase price for the Quebec assets of Asbestos Corporation Limited (ACL). GDC owns 54.6 per cent of the 2.8 million outstanding common shares of ACL.

The constitutionality of Bill 70 and of Bill 121, the expropriation legislation adopted by Quebec in June 1979, was upheld in a

TABLE 1. CANADA, ASBESTOS PRODUCTION AND TRADE, 1979 AND 1980

	1979		1980^{p}	
	(tonnes)	($)	(tonnes)	($)
Production (shipments)[1]				
By type				
Crude, groups 1, 2 and other milled	4	12,553	-	-
Group 3, spinning	23 958	24,716,343	19 000	..
Group 4, shingle	502 248	342,034,640	486 000	..
Group 5, paper	199 443	96,532,640	192 000	..
Group 6, stucco	246 487	72,322,775	222 000	..
Group 7, refuse	520 579	71,841,864	416 000	..
Group 8, sand	-	-	-	-
Total	1 492 719	607,460,815	1 335 000	641,737,000
By province				
Quebec	1 327 980	505,698,707	1 169 000	518,714,000
British Columbia	94 286	65,520,069	102 000	84,098,000
Newfoundland	70 453	36,242,039	64 000	38,925,000
Total	1 492 719	607,460,815	1 335 000	641,737,000
Exports				
Crude				
United States	20	12,000	-	-
Total	20	12,000	-	-
Milled fibre (groups 3, 4 and 5)				
West Germany	121 826	80,358,000	117 282	80,802,000
United States	107 353	76,274,000	62 206	49,015,000
United Kingdom	44 547	35,331,000	49 788	42,142,000
France	38 457	24,972,000	48 538	35,279,000
Mexico	40 351	28,780,000	32 294	25,783,000
Japan	38 348	22,114,000	40 445	25,666,000
Italy	25 262	18,777,000	28 148	23,257,000
India	30 971	22,063,000	25 378	21,399,000
Malaysia	18 624	12,477,000	21 099	15,451,000
Belgium-Luxembourg	10 449	6,861,000	16 706	12,330,000
Australia	18 186	12,348,000	14 681	12,229,000
Nigeria	3 988	2,874,000	16 781	11,760,000
Colombia	13 343	7,813,000	14 683	9,962,000
Other countries	207 370	145,968,000	162 849	127,790,000
Total	719 075	497,010,000	650 878	492,865,000
Shorts (groups 6, 7, 8 and 9)				
United States	397 563	72,490,000	261 845	53,408,000
Japan	97 165	26,318,000	91 402	27,342,000
West Germany	32 016	6,727,000	31 783	8,206,000
United Kingdom	50 749	10,240,000	29 606	6,326,000
France	20 110	4,370,000	20 154	4,683,000
Taiwan	5 600	1,722,000	8 335	2,980,000
Belgium-Luxembourg	10 642	2,804,000	8 414	2,603,000
Mexico	10 315	2,842,000	9 369	2,144,000

TABLE 1. (cont'd)

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Shorts (cont'd)				
Algeria	-	-	4 995	2,087,000
Thailand	6 247	2,012,000	5 780	2,070,000
Argentina	8 824	2,029,000	7 729	1,936,000
Nigeria	1 448	349,000	7 710	1,920,000
Netherlands	18 582	3,507,000	9 282	1,759,000
Columbia	4 188	728,000	7 269	1,616,000
Spain	8 391	2,461,000	4 976	1,545,000
Other countries	70 107	16,975,000	51 026	13,012,000
Total	741 947	155,574,000	559 675	133,637,000
Grand total crude, milled fibres and shorts	1 461 042	652,596,000	1 210 553	626,502,000
Manufactured products				
Asbestos cloth, dryer felts, sheets				
United States		5,355,000		3,610,000
United Kingdom		564,000		674,000
Singapore		77,000		91,000
Taiwan		65,000		90,000
Australia		35,000		73,000
West Germany		-		37,000
Other countries		282,000		169,000
Total		6,378,000		4,744,000
Brake linings and clutch facings				
United States		2,489,000		2,453,000
Australia		255,000		261,000
Hong Kong		145,000		201,000
France		152,000		65,000
West Germany		-		56,000
Ecuador		158,000		37,000
Uruguay		29,000		27,000
Lebanon		17,000		23,000
Guatemala		5,000		15,000
Other countries		138,000		97,000
Total		3,388,000		3,235,000
Asbestos and asbestos cement building materials				
United States		13,884,000		11,978,000
Thailand		98,000		1,184,000
United Kingdom		899,000		894,000
Libya		-		494,000
Singapore		349,000		342,000
Emirates, U.A.		177,000		333,000
Kuwait		23,000		249,000
Australia		95,000		193,000
France		1,000		158,000
Other countries		1,278,000		711,000
Total		16,804,000		16,536,000

TABLE 1. (cont'd)

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Asbestos basic products, nes				
United States		9,618,000		11,643,000
West Germany		7,000		659,000
Australia		68,000		270,000
Venezuela		17,000		140,000
Taiwan		-		73,000
Other countries		396,000		455,000
Total		10,106,000		13,240,000
Total exports, asbestos manufactured		36,676,000		37,755,000
Imports				
Asbestos, unmanufactured	1 953	1,008,000	1 156	889,000
Asbestos, manufactured				
Cloth, dryer felts, sheets, woven or felted		2,813,000		2,422,000
Packing		2,921,000		3,211,000
Brake linings		7,843,000		6,617,000
Clutch facings		1,702,000		1,634,000
Asbestos-cement shingles and siding		26,000		58,000
Asbestos-cement board and sheets		639,000		840,000
Asbestos building materials, nes		4,472,000		3,530,000
Asbestos basic products, nes		6,101,000		5,153,000
Total asbestos, manufactured		26,517,000		23,465,000
Total asbestos, unmanufactured and manufactured		27,525,000		24,354,000

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Value of containers not included.
P Preliminary; - Nil; nes Not elsewhere specified; .. Not available.

Quebec Superior Court ruling on May 26, 1980. The ruling, in effect, gives a provincial government the right to expropriate its natural resources no matter how great the financial impact on the company that owns them. ACL had contended that a province does not have the right to expropriate a federally chartered company and to handicap a company, the sole object of which is mining, milling and marketing of asbestos. Also, it was challenged that the legislation was unconstitutional because the laws were adopted in the French language only. The Court ruled also that Law 82, which retroactively validated about 300 laws originally passed in French only, was a fair solution to a Supreme Court of Canada ruling in December, 1979 that laws must be in French and English. An Appeals Court ruling in March, 1981 ruled that Bill 121 is constitutionally valid. ACL immediately appealed the lower court decision to the Supreme Court of Canada and sought a restraining order to stop expropriation. The Supreme Court of Canada rejected ACL's application for an injunction and refused to hear the company's appeal in a decision on March 16, 1981, effectively removing the last barrier to government expropriation of ACL assets in Quebec. ACL and the Quebec

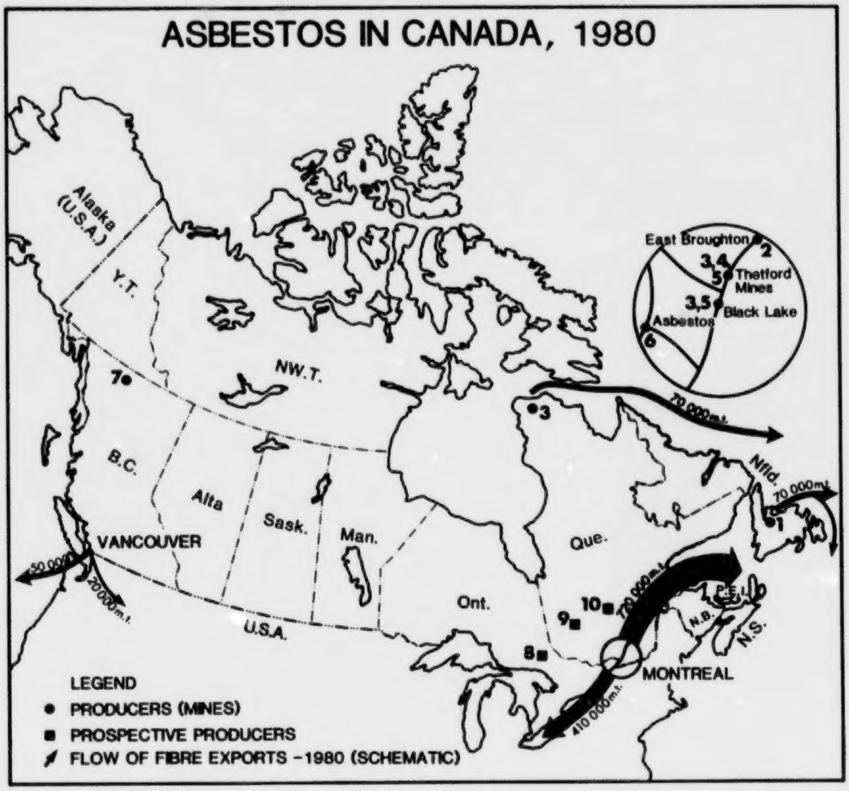

ASBESTOS IN CANADA, 1980
Alaska (U.S.A.)
Y.T.
NW.T.
B.C.
Alta
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
VANCOUVER
MONTREAL
East Broughton
Thetford Mines
Black Lake
Asbestos
1
2
3
3,4
5
3,5
6
7
8
9
10
70 000 m.t.
70 000 m.t.
50 000
20 000 m.t.
410 000 m.t.
LEGEND
● PRODUCERS (MINES)
■ PROSPECTIVE PRODUCERS
FLOW OF FIBRE EXPORTS -1980 (SCHEMATIC)

FIGURE 1
(numbers on map refer to Table 2 on following page)

government agreed soon after to establish a timetable for talks aimed at negotiating a fair price for an acquisition by Quebec.

An agreement allowing Quebec to purchase Bell Asbestos Mines, Ltd. and two asbestos-cement product plants, Atlas Turner Inc., Montreal and Turners Building Products Ltd., Mission, British Columbia, was concluded in May, 1980. The mine and products plants are owned by Turner & Newall Limited of the United Kingdom.

Mine location and mill capacity data are indicated in Figure 1 and Table 2. Asbestos Corporation Limited continued to study the feasibility of mining, by underground methods, the Penhale orebody below the exhausted Normandie pit in the Black Lake region of Quebec and also the feasibility of underground mining at Asbestos Hill in the Ungava area. Johns-Manville Canada Inc. proceeded with its capital expenditure program to assure a continued large supply of fibre from the Jeffrey mine-mill complex at

TABLE 2. CANADIAN ASBESTOS PRODUCERS AND PROSPECTIVE PRODUCERS, 1980

(numbers refer to map on previous page)	Mine Location	Mill Capacity (tonnes)		Remarks
		ore/day	fibre/year	
Producers				
1. Advocate Mines Limited	Baie Verte, Nfld.	6 600	80 000	Open-pit. Produces groups 4 and 6.
2. Carey Canada Inc.	East Broughton, Que.	6 800	210 000	Open-pit. Mainly produces groups 6 and 7.
3. Asbestos Corporation Limited				World's major independent asbestos producer.
Asbestos Hill mine	Putuniq, Que.	5 400	90 000	Annual rated capacity 272 000 tonnes concentrate. Final processing of fibre in West Germany.
British Canadian mine	Black Lake, Que.	12 000	210 000	Open-pit, two milling plants.
King-Beaver mine	Thetford Mines, Que.	7 000		Underground and open-pit.
Normandie mine	Black Lake, Que.			Reserves exhausted. Mill processes K-B open-pit ore.
4. Bell Asbestos Mines, Ltd.	Thetford Mines, Que.	2 700	55 000	Underground. Purchased by Quebec government.
5. Lake Asbestos of Quebec, Ltd.	Black Lake, Que.	9 000	235 000	Open-pit.
National Mines Division	Thetford Mines, Que.	4 000		Open-pit.
6. Johns-Manville Canada Inc. Jeffrey mine	Asbestos, Que.	30 000	645 000	Open-pit (western world's largest known asbestos deposit).
7. Cassiar Resources Limited Cassiar mine	Cassiar, B.C.	3 000	100 000+	Open-pit. Acquired by Brinco Mining Limited in 1981.
Prospective Producers				
8. United Asbestos Inc.	Matachewan, Ont.	3 600	100 000	Inactive. Operated from late 1975 to March 1977.
9. Abitibi Asbestos Mining Company Limited	Amos, Que.	11 800		Feasibility study has been undertaken.
10. McAdam Mining Corporation Limited	Chibougamau, Que.	4 500		Feasibility study has been undertaken.

Sources: Energy, Mines and Resources Canada; The Quebec Asbestos Mining Association, Quebec.

Asbestos, Quebec. Expenditures by Carey Canada Inc. and Lake Asbestos of Quebec, Ltd. were directed primarily to upgrading of environmental controls. Modernization and mechanization programs continued at Bell Asbestos Mines, Ltd., while Cassiar Resources Limited directed initiatives to improved environmental control and an exploratory drilling program designed to increase mine ore reserves. All of the outstanding shares of Cassiar Resources were acquired early in 1981 by Brinco Limited and this holding was turned over to Brinex Limited, a wholly owned subsidiary.

PROSPECTIVE PRODUCERS

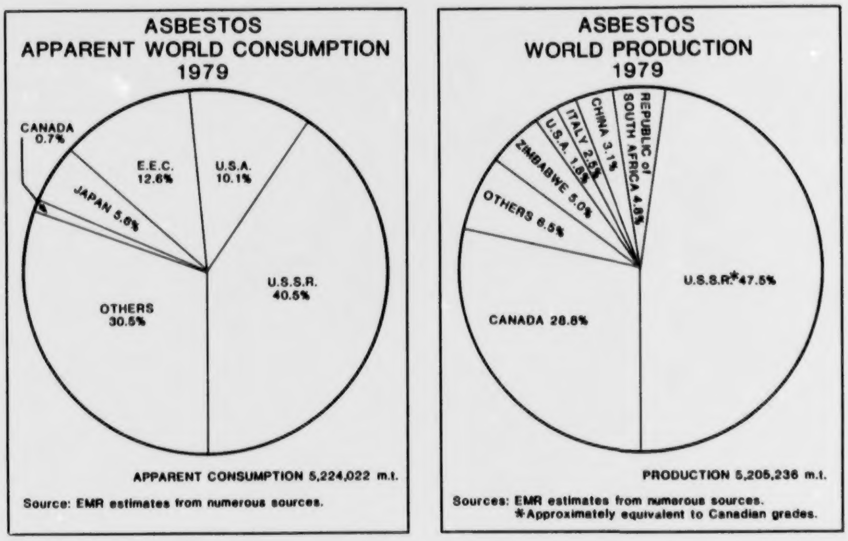
There were no production plans announced during 1980 by companies with properties offering potential opportunities for development.

WORLD PRODUCTION AND DEVELOPMENTS IN MAJOR MARKETS

Total world production of asbestos in 1980 was an estimated 5.0 million t based on the inclusion of Russian grades approximately equivalent to Canadian grades. Chrysotile accounted for about 90 per cent of the world production and the remaining production consisted of about 6 per cent crocidolite (blue asbestos) and 3 per cent amosite. Less than 1 per cent of other types of asbestos, including tremolite and anthophyllite, was produced, mainly in the United States.

The diagrams show a breakdown of 1979 world production and world consumption by country. Discrepancies occur in the data available from the U.S.S.R. and also in the interpretation of this data, resulting in problems of statistical correlation. Most of the annual output from the U.S.S.R. is consumed domestically, although about 600 000 t are exported, mainly to eastern European countries, Japan, France, West Germany and India.

The three major producers in the U.S.S.R. are: the Uralasbest Combine in the Central Urals, near Sverdlovsk; the Kustanaiasbest Combine in the Dzhetygara district of Northwest Kazakhstan, along the eastern flank of the southern Urals; and the Tuvaasbest Combine in the Tuva district west of Lake Baikal. At the new Kiembay development in the southern Urals, several Council for Mutual Economic Assistance (COMECON) countries are assisting in the completion of a project designed to produce



Source: EMR estimates from numerous sources.

Sources: EMR estimates from numerous sources.
*Approximately equivalent to Canadian grades.

FIGURE 2

550 000 tpy of asbestos. The COMECON countries are expected to receive most of the output from this new project.

The Republic of South Africa has the only commercial deposit of amosite and is also the major producer of crocidolite and chrysotile. Normally, about 30 per cent of this country's annual production of about 300 000 t is chrysotile.

Official figures for asbestos output have not been available from Zimbabwe (formerly Rhodesia) since the country's Unilateral Declaration of Independence in November 1965, and subsequent imposition of U.N. trade sanctions. Zimbabwe was the third largest producer of asbestos in the western world, after Canada and Republic of South Africa, and the country undoubtedly remains a world ranking producer with an estimated output of about 250 000 tpy. Following the peace settlement it was announced that the new government had no intention of nationalizing the mining sector or of making changes to an industry which was the major foreign currency earner and a large employer.

United States production of approximately 90 000 tpy is from California, Vermont and Arizona. Significant changes in levels of production are not expected. The United States produces approximately 16 per cent of its asbestos needs and imports the remainder, practically all of which is chrysotile from Canada. Hearings on a proposal in 1975 by the Occupational Safety and Health Administration (OSHA) to limit worker exposure to 1.0 fibres per cubic centimetre of air have never been scheduled. The United States Supreme Court, upholding an October 1978 judgement, struck a blow to OSHA's cancer policy based on the idea that there is no safe level of exposure to a cancer-causing agent and that exposure must be reduced to as low a level as technically and economically possible. The decision (Industrial Union Dept. AFL-CIO vs. American Petroleum Institute) invalidated a workplace standard promulgated by the Secretary of Labour with respect to exposure to benzene, thereby establishing a precedent limiting OSHA ability to promulgate standards without first making a threshold finding of significant risk. The Court noted that the purpose of such standards is to eliminate significant harm, not to provide absolute safety. It is uncertain if this ruling will influence OSHA's approach to lowering the present asbestos standard of 2 fibres/cc. The Interagency Regulatory Liaison Group, the Environmental Protection Agency (EPA), and the Consumer Product Safety Commission held a National Workshop on Substitutes for Asbestos in July. Conclusions from this fact-gathering exercise demonstrated that there are substitutes for asbestos in most applications but substitute-containing products would likely be inferior in quality and more costly compared with those containing asbestos. The health effects of the proposed substitutes were largely unknown.

In Australia, the Industries Assistance Commission Report on Asbestos dated October 30, 1979 recommended that no assistance be accorded the production in Australia of asbestos falling within the applicable customs tariff; thus, asbestos will continue to be allowed to enter free of duty. However, Woodsreef Mines Limited, N.S.W., the country's only asbestos producer, made plans for a financial restructuring which the company expects will enable it to operate and trade profitably in the future.

In Greece plans for construction of an $85 million project to develop a major asbestos deposit were announced by an affiliate of the World Bank which will finance the project jointly with the Hellenic Industrial Development Bank. The project will have an initial annual capacity of 100 000 t of asbestos fibre, principally for export.

Asbestos projects in various stages of exploration or development are under way in Brazil, Sudan, Colombia and Mexico.

FIBRE GROUPS, USES AND TECHNOLOGY

The particular properties that give asbestos commercial value are fibrous structure, high tensile strength that imparts reinforcing characteristics to numerous products and resistance to high temperature and to certain types of chemical attack.

Asbestos is classified and priced by groups from the longest fibre, corresponding to No. 1, to the shortest, No. 7. Groups 8 and 9 are sold on the basis of bulk measure. There are more than 3,000 uses for asbestos and it is more appropriate to classify the groups in categories and describe the major purposes the fibres serve than to list the products in which they are used.

Long fibres, Crudes No. 1 and 2 and Group 3 are used in the textile industry, as electrical insulation, as a filtration medium and as reinforcing fillers in asbestos-cement products where great strength is required.

Medium-length fibres, Groups 4, 5 and 6 are used as reinforcing fillers in asbestos-cement products, friction materials such as brake lining and clutch facings; and in paper and pipe coverings.

Short fibres, Groups 7, 8 and 9 are used as reinforcing fillers in plastics, floor tile, asphalt, and in paints and oil-well muds.

In the United States, by far Canada's major market, about 60 per cent of asbestos is used in the construction industry for roofing and flooring products and asbestos-cement pipes and sheets. A breakdown of the total apparent consumption of asbestos in the United States is as follows: asbestos-cement pipe, 38 per cent; flooring products, 21 per cent; roofing products, 12 per cent; friction products, 11 per cent; insulation, coatings and compounds, packings and gaskets, 3 per cent each; paper, plastics and textiles, 1 per cent each and minor uses the remainder.

Federal emission regulations in Canada pursuant to the Clean Air Act and as recommended by the Department of the Environment (DOE) require that the concentration of asbestos fibres contained in emissions to the ambient air at a mine or mill, from crushing, drying or milling operations, or from dry rock storage, shall not exceed two asbestos fibres per cubic centimetre (cc). Fibres are defined as those greater than five microns in length with an aspect ratio of at least three to one. Quebec in-plant regulations, based on recommendations made in 1976 by the Beaudry Study Committee, are determined by the level of total respirable dust, asbestos content of the total respirable dust and the number of fibres greater than five microns in length. The average concentration of fibre is restricted to two fibres/cc or lower in order to satisfy the maximum, never-to-exceed limit, of five fibres/cc. A maximum of five milligrams (mg)/cubic metre (m^3) of total respirable dust is allowed in the workplace and a maximum of 0.20 mg/m^3 of total respirable dust is allowed in the return air flow. British Columbia and Newfoundland in-plant regulations restrict the level of airborne asbestos in the working environment to two fibres/cc, following current standards established by the American Conference of Governmental Industrial Hygienists.

TABLE 3. CANADA, ASBESTOS PRODUCTION AND EXPORTS, 1970, 1975-80^p

	Crude	Milled	Shorts	Total
	(tonnes)			
Production[1]				
1970	6 579	668 629	832 210	1 507 418
1975	5	480 579	575 083	1 055 667
1976	27	681 003	855 061	1 536 091
1977	1	762 186	755 173	1 517 360
1978	1	673 910	747 897	1 421 808
1979	4	725 649	767 066	1 492 719
1980^p	-	697 000	638 000	1 335 000
Exports				
1970	91	747 814	669 509	1 417 414
1975	183	570 418	514 997	1 085 598
1976	83	725 197	777 154	1 502 434
1977	1	705 832	709 649	1 415 482
1978	1	689 690	708 392	1 398 083
1979	20	719 075^r	741 947^r	1 461 042^r
1980^p	-	650 878	559 675	1 210 553

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Producers' shipments.
^{p} Preliminary; ^{r} Revised; - Nil.

The federal Department of Consumer and Corporate Affairs banned, under the Hazardous Products Act, certain asbestos-containing products. The ban affected the sale, importation and advertising of drywall joint cements or compounds, or patching and spackling compounds that are for use in construction or repairs. Other products previously banned included modelling or sculpturing clays containing asbestos that may become separated from the products.

The Ontario Ministry of Labour established in April a three-man Royal Commission to investigate the health effects of exposure to asbestos fibres and to recommend safety standards. The first public meeting was held in October and hearings and written submissions are scheduled until mid-1981. The Commission will deal with issues such as: Health Effects of Asbestos, Worker Exposure to Asbestos in the Workplace and In-plant Control, Asbestos in

Public Buildings, Other Asbestos Exposure, Institutional and Policy Issues including review of laws and regulations in Ontario and elsewhere, Measurement Problems and Workmen's Compensation Practices.

The Asbestos subgroup under the Canada-European Economic Community (EEC) Minerals and Metals Working Group continued to meet at intervals. This subgroup, established under the 1976 E.C./Canada Framework Agreement for Commercial and Economic Cooperation, is presently concerned with problems of fibre measurement and the exchange of scientists to standardize terminology and procedures. Some other subjects that may be included for cooperative study are: epidemiological research, emission control techniques and economic implications, research reference catalogues and harmonization of labelling and transportation practises.

Johns-Manville Canada Inc. discontinued asbestos-cement pipe manufacturing operations at its Port Union Plant in Scarborough, Ontario. The decision reflected declining market demand for a/c pipe in North America.

Personal injury actions against numerous producers of asbestos and asbestos-based products continue in the United States. Suits typically allege that companies failed in their duty to warn of the hazards of inhalation of asbestos fibre in dust originating from certain asbestoscontaining products or to warn of hazards associated with the use of fibre in certain product manufacturing plants.

OUTLOOK

Weak economic conditions and continued emphasis on the adoption of substitutes where possible are expected to contribute to weak demand for asbestos, particularly in the United States. From a 1979 base, U.S. demand is expected to show no growth through 1990, according to the United States Bureau of Mines. However, a slower rate of growth in demand for asbestos in some of the industrialized countries is expected to be offset by increased demand in the developing countries. As a result, average annual growth in demand for asbestos in the western world is estimated to be approximately 1.5 per cent over the next several years.

Expansion of the Canadian asbestos mining industry will be influenced by the environmental control and product-use regulations finally adopted in the United States and the European Economic Community because approximately 60 per cent of current Canadian asbestos exports are to these markets. Environmental-health studies are ongoing in the industrialized countries and most regulatory bodies assume that the public and the workplace can be satisfactorily protected from the risks associated with asbestos exposure through appropriate regulations and their enforcement.

Overly restrictive legislation aimed at phasing asbestos out of use may prove self-defeating according to some authorities who seriously question the merits of a broad shift to the use of substitutes when relatively less is known about possible health hazards associated with these physically similar materials. A consideration gaining increased importance is that asbestos represents the known risk against the unknown and in nearly every case the substitute is a different material (glass fibre, ceramic fibre, silica fibre, aromatic polyamindes, carbon fibre) resulting in fragmented markets tending to be served at increased cost.

Quebec asbestos producer prices were increased about 8 per cent effective January 1, 1980. Cassiar Resources Limited increased prices about 17 per cent on January 1, 1980 and a further 11 per cent on January 1, 1981.

PRICES

Canadian asbestos prices quoted in **Asbestos** December, 1980[1].

	January 1, 1980 ($ per short ton)
Asbestos Corporation, fob mine	
Group	
No. 3 (spinning fibre)	1,125 - 1,750
No. 4 (asbestos-cement fibre)	846 - 1,102
No. 5 (paper fibre)	530 - 626
No. 6 (waste, stucco, plaster)	380
No. 7 (refuse, shorts)	122 - 233

PRICES (Cont'd)

	January 1, 1980 ($ per short ton)
Cassiar, fob North Vancouver, B.C.	
Canadian group	
No. 3 (nonferrous spinning fibre)	
AAA grade	2,000
AA grade	1,600
A grade	1,150
Ac grade	1,050
No. 4 AK grade (single fibre asbestos-cement)	975
No. 4 AS grade	900
No. 4 AX grade	825
No. 5 AY grade	575
No. 6 AZ grade	375

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[1] **Asbestos** is a magazine published monthly by Stover Publishing Company.

TARIFFS

Canada

Item No.		British Preferential (%)	Most Favoured Nation (%)	General (%)	General Preferential (%)
31210-1	Asbestos, crude	free	free	25	free
31215-1	Asbestos, yarns, wholly or in part of asbestos, for use in manufacture of clutch facings and brake linings	7.3	7.3	25	4.5
31225-1	Asbestos felt, rubber impregnated for use in manufacturing floor coverings	free	free	25	free
31200-1	Asbestos, in any form other than crude, and all manufactures thereof, n.o.p.	11.9	11.9	25	7.5
31205-1	Asbestos in any form other than crude, and all manufactures thereof, when made from crude asbestos of British Commonwealth origin, n.o.p.	free	11.9	25	free
31220-1	Asbestos woven fabric, wholly or in part of asbestos for use in manufacture of clutch facings and brake linings	11.9	11.9	30	7.5

United States

Item No.		
518.11	Asbestos, not manufactured, crudes, fibres, etc.	free
518.41	Pipes, tubes, fittings	0.15¢ per lb

United States (Cont'd)

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
518.44	Other asbestos cement articles	Remain free			

		1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
518.21	Asbestos, yarn, slivers, cloth, etc.	3.5	3.0	2.5	2.0	1.5	1.0	0.5	free
518.51	Asbestos articles nop	3.9	3.4	2.8	2.3	1.7	1.1	0.6	free

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States, Annotated 1980, USITC Publication 1011. U.S. Federal Register Vol. 44, No. 241.
nop Not otherwise provided for.

Barite and Celestite

G.O. VAGT

Canadian shipments of barite in 1980 were valued at $2.56 million, while imports of barium carbonate, one of the most important barium chemicals derived from barite, amounted to 3 231 tonnes (t) valued at $1,109,000.

Barite ($BaSO_4$) is a valuable industrial mineral because of its high specific gravity (4.5), low abrasiveness, chemical stability and lack of magnetic and toxic effects. Its dominant use is as a weighing agent in the oil- and gas-well drilling muds required to counteract high pressures confined by the substrata.

Barite is found in many countries of the world and is the raw material from which nearly all other barium compounds are derived. Witherite ($BaCO_3$) was formerly of importance but it has been found in relatively large quantities only in the north of England. The major western world producers of barite are: the United States, Peru, India, Ireland, Mexico and Morocco.

PRODUCTION AND OCCURRENCES IN CANADA

Barite occurs in a variety of geological environments: as the principal mineral in veins and cavity fillings, often along with fluorite, calcite and quartz; as a gangue mineral in some lead-zinc-silver deposits; as bedded or irregular replacement deposits in sedimentary rocks; and as residual deposits. Pure barite is white and is most common in veins; impure barite may be near-white, grey, brown or light red. Barite was produced during 1980 from operations in British Columbia and Ontario.

Mountain Minerals Co. Ltd. mines barite underground from vein deposits near Parson and Brisco in eastern British Columbia, and recovers crude barite from lead-zinc tailings at the Mineral King mine near Invermere. All of the crude barite is shipped to the company's grinding plant at Lethbridge, Alberta. Baroid of Canada, Ltd. processes imported crude barite at its grinding plant in Onoway, Alberta.

Extender Minerals of Canada Limited operates a mine near Matachewan, Ontario from which barite is produced from a vein deposit by open-pit methods, with all beneficiation being done on the site.

There are many occurrences of barite across Canada. Of note are those at Buchans, Newfoundland where there is an estimated 0.5 million t of barite in tailings; in Nova Scotia, near Brookfield on the mainland, and east of Lake Ainslie on Cape Breton Island; in northern Ontario, in Yarrow, Penhorwood and Langmuir townships, and on McKellar Island in Lake Superior; near mile 397 of the Alaska Highway in British Columbia; north of mile 548 of the Alaska Highway in British Columbia and in the Yukon Territory, notably in the Macmillan Pass region, at locations near the Dempster Highway and at 48 kilometres (km) northeast of Watson Lake (Mel Deposit).

TABLE 1. CANADA, BARITE PRODUCTION, TRADE AND CONSUMPTION, 1979 AND 1980

	1979		1980^P	
	(tonnes)	($)	(tonnes)	($)
Production (mine shipments)	..	1,953,000	..	2,562,000
Imports				
United States	8 389	1,403,000	48 522	4,130,000
United Kingdom	9	1,000	101	54,000
Other	-	-	126	31,000
Total	8 398	1,404,000	48 749	4,215,000
Exports				
United States	2 038	49,000	645	212,000
Total	2 038	49,000	645	212,000
	1978		1979	
Consumption[1]				
Well drilling	$53\ 000^e$		$75\ 000^e$	
Rubber goods	2 977		1 076	
Paint and varnish	1 071		2 694	
Glass and glass products[2]	13		7	
Other[3]	1 062		818	
Total	58 123		79 595	

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Available data reported by consumers with estimates by Energy, Mines and Resources Canada. [2] Includes glass fibre and glass wool. [3] Other includes bearings and brake linings, ceramics, chemicals and plastics.
P Preliminary; ^{e} Estimated; .. Not available; - Nil.

Production in 1981 is expected to be realized from the Buchans mine because Abitibi-Price Inc. and ASARCO Incorporated completed separate agreements for the sale of barite to Baroid of Canada, Ltd. The mine is 51 per cent owned by Abitibi and 49 per cent by ASARCO. The Lake Ainslie deposit on Cape Breton Island contains about 4.5 million t of ore grading 33 per cent barite and 17 per cent fluorspar. International Mogul Mines Limited recently carried out limited metallurgical tests on samples from the prospect.

USES, CONSUMPTION AND TRADE

The dominant use for barite is as a weighting agent in oil- and gas-well drilling muds to control their density. Principal specifications are usually a minimum specific gravity of about 4.0, a particle size of at least 95 per cent minus 325 mesh, and a maximum water-soluble solids content of 250 ppm.

In 1979, consumption of barite in Canada was an estimated 79 595 t with over 90 per cent of this utilized in drilling muds. Table 4 summarizes the apparent consumption of barite in relation to wells drilled. Data on stocks is not available.

Barite is used in paint as a special filler or "extender pigment". This is a vital constituent that provides bulk, improves consistency of texture, surface characteristics and application properties, and controls prime pigment settling and the viscosity of paints. Specifications for barite used in the paint industry call for 95 per cent $BaSO_4$, particle size at least minus 200 mesh, and a high degree of whiteness or light reflectance. Final "wet milled" and "floated" products result in smooth micro-crystalline surfaces that prevent agglomeration, thus allowing easy dispersal in water as well as in oil-soluble binders. When barite is used in highly pigmented distemper or latex paints, a degree of light scattering is attributed to the barite, therefore allowing it to function as a pigment.

TABLE 2. CANADA, BARITE PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975-80

	Production[1]	Imports	Exports	Consumption[2]
	($)	(tonnes)		
1970	1,388,125	6 827	90 305	50 106
1975	2,305,819	4 479	45 606	40 229
1976	1,852,254	18 097	60 297	58 066
1977	2,836,241	5 979	69 421	53 508
1978	2,656,672	15 635	56 783	58 191
1979	1,953,000	8 398	2 038	58 123
1980P	2,562,000	48 749	645	79 595

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Mine shipments. [2] Apparent consumption.
P Preliminary.

The glass industry uses barite to increase the workability of glass, to act as a flux, assist decolouration and increase the brilliance or lustre of the product. Specifications call for a minimum of 96 to 98 per cent $BaSO_4$, a particle size range of 40 to 140 mesh and usually a magnetically separated ore is used with iron often reduced to 0.1 per cent. However, producers of fine glassware use precipitated barium carbonate to circumvent impurity problems often associated with natural barite.

The specifications for natural barite used as a filler in rubber goods vary, but the main factors are whiteness and particle size range. For general filler and extender uses most manufacturers want a fine-grained product that is virtually all minus 325 mesh. Colour is important to many users.

The balance of Canada's barite consumption in 1980 was in the manufacture of ceramic products, chemicals, plastics and brake linings. Barite may become an important ingredient in heavy concrete for nuclear reactors because it reduces the amount of lead shielding required.

There is no barium chemicals industry in Canada. Some important barium chemicals include the nitrate, acetate, oxide, hydroxide and stearate compound, all derived from barium carbonate. Two other important compounds are chemical or precipitated barium sulphate, referred to in the trade as blanc

TABLE 3. WORLD MINE PRODUCTION OF BARITE 1978-80 AND RESERVES, 1980

	Mine production			Reserves
	1978	1979	1980[e]	1980
	(000 tonnes)			
United States	1 916	1 843	2 359	50 000
Peru	362	363	408	6 000
India	351	387	363	27 000
Thailand	275	378	363	9 000
Ireland	349	363	345	8 000
France	225	227	227	5 000
Italy	237	215	227	5 000
Morocco	177	230	227	3 000
Mexico	231	151	181	9 000
West Germany	169	161	163	5 000
Yugoslavia	53	54	73	3 000
Canada	..	..	..	15 000
Other free-world countries	1 181	934	907	20 000
Communist countries	1 200	1 329	1 451	20 000
World totals	6 726	6 635	7 294	185 000

Sources: United States Bureau of Mines, Mineral Commodity Summaries, 1981. U.S. Bureau of Mines Preprints 1978-79.

[e] Estimated; .. Not available.

TABLE 4. CANADA, OIL AND GAS WELLS DRILLED AND APPARENT CONSUMPTION OF BARITE, 1971-80

Year	Wells Drilled	Metres Drilled	Apparent Consumption		Major Regions			Remarks
					Alta.	Yukon, NWT & Arctic Islands	Eastern Canada	
	(no.)	(millions)	(tonnes)	(t/1000 m)	(% of total metreage)			
1980	9,188 (+19%)	10.5 (+21%)	144 000P +(92%)	13.7				
1979	7,701 (+1%)	8.7 (+14.5%)	75 000P +(13%)	8.6	78.4	0.6	2.2	Increased metreage mainly result of greater average depth of Alberta wells. Eastern Canada metreage increase mainly in East coast offshore and Ontario.
1978	7,612	7.6 (+22.5%)	53 068 (+9.2%)	7.0	79.2	0.7	2.0	
1977	6,123	6.3 (+12.7%)	48 582 (-12.7%)	7.7	82.2	1.3	1.7	NWT and Arctic Is. drilling decreased moderately from previous two years. East coast drilling decreased to one-third the level in the previous two years.
1976	5,584	5.5 (+30.9%)	58 066 (+51.9%)	10.6	87.1	1.5	2.0	
1975	4,200	4.2 (-5%)	36 044 (-43%)	8.6	86.7	2.7	2.7	Drilling in NWT, Arctic Is. and eastern Canada decreased to one-quarter of the average level in the previous four years.
1974	4,335	4.4 (-16%)	51 522 m.t. (-29%)	11.7	82.7	3.5	3.2	
1973	4,886	5.09 (+18.6%)	66 481 m.t. (+8.1%)	13.1	76.0	4.4	3.6	
1972	3,809	4.3 (+19.4%)	61 482 m.t. (+36%)	14.3	71.2	4.1	3.6	
1971	3,091	3.6	45 078	12.5	67.8	4.0	4.1	Additional discoveries made in MacKenzie Delta and Arctic Islands. Sable Is. field discovered.

Sources: Canadian Petroleum Association; Statistics Canada; Energy, Mines and Resources Canada.

m metre; ( ) percentage change from previous year; P Preliminary.

fixe; and lithopone, a chemically precipitated mixture of 70 per cent barium sulphate and 30 per cent zinc sulphide. Lithopone, a white pigment, is still in demand for purposes such as vehicle undercoatings, filling pastes, emulsion paints and wallpaper coatings. However, lithopone has largely been replaced by titanium dioxide pigments in most uses.

Specifications of barite for the barium chemicals industry call for 95 per cent $BaSO_4$, and not more than 2 per cent Fe_2O_3.

WORLD REVIEW

World production of barite in 1980 was an estimated 7.5 million t, according to the United States Bureau of Mines. An estimated 75 per cent of this quantity was consumed in oil-well drilling operations and most barite was supplied by oil-field service companies closely inter-related with the drilling companies. Most of these companies are controlled or associated with one of the following major United States organizations: Baroid Division of N L Industries, Inc.; Dresser Industries, Inc.; Milchem, Inc.; and Imco Drilling Services, a division of Halliburton Company. World demand is most economically served by production from many countries and the viability of any deposit is mainly influenced by transportation costs to markets.

The United States is by far the world's largest producer of barite and its mines produced an estimated 2.04 million t in 1980, derived mainly from Nevada, Arkansas and Missouri. More than 90 per cent of this production was used as a weighting agent in drilling muds. Annual imports of barite to the U.S. during 1979 and 1980 were 1.35 and 1.81 million t respectively. Following the United States, which accounted for 27.0 per cent of the total world production, were: Peru, 6.0 per cent; India, 4.6; Ireland, 4.4; Mexico, 4.4; Morocco, 4.2; Thailand, 1.0; France, 3.0; Italy, 2.9; Chile, 2.7; West Germany, Iran and Turkey, each with 2.0; Brazil, 1.4; Algeria, 1.2; Canada, 1.1; other market economy countries, 6.4; and other central-economy countries, except Yugoslavia, 20.7.

The United States, the principal consumer of barite, used an estimated 3.8 million t in 1980. Imports into the United States for the years 1976 to 1979, inclusive, came from: Peru, 26 per cent; Ireland, 17 per cent; Mexico, 10 per cent; Morocco, 9 per cent and other, 38 per cent.

In the U.S., new grinding plant construction or expansions, particularly along the Gulf Coast, continued during the year. The phased decontrol of oil prices put into effect in mid-1979 is expected to result in increased drilling activity; consequently, total demand for barite is forecast by the United States Bureau of Mines to increase about 7 per cent annually in the 1980-85 period. In Thailand, a barite mine was being developed by Chromalloy American Corporation, and in Belgium production began from a gravity concentrating plant owned by NL Baroid division of N L Industries, Inc.

PRICES

Listed prices of domestic U.S. drilling mud-grade barite increased about 12 per cent. In Canada, federal government incentives, based on the National Energy Program announced in October 1980, are expected to result in an increased emphasis on offshore oil and gas exploration. This almost assures that the offshore demand for

United States prices of barite as reported in **Engineering and Mining Journal**[1], of October 1980.

	($ per short ton)
Unground	
Chemical and glass grade:	
Hand picked, 95% $BaSO_4$, not over 1% Fe	66.00
Magnetic or flotation, 96-98% $BaSO_4$, not over 0.5% Fe	60.00-70.00
Imported drilling mud grade, specific gravity 4.20 - 4.30, cif	
Gulf ports	30.00-60.00
Ground	
Water ground, 95% $BaSO_4$ 325 mesh, 50-lb bags	80.00-133.00
Dry ground, drilling mud grade, 83%-93% $BaSO_4$, 3-12% Fe, specific gravity 4.20-4.30	70.00-90.00
Imported	
Specific gravity 4.20-4.30	50.00-60.00

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[1] Published by McGraw-Hill.

barite will increase during the next several years. In addition, the trend toward deeper wells may result in more barite being consumed in some areas.

There is good potential for discovery and development of barite deposits near most regions where there is drilling activity, however, increasing rail transportation rates in North America may provide additional incentives to overseas suppliers. On the other hand, restrictions on exports of crude barite in favour of ground barite, or other possible disruptions to world trade, could place more emphasis on exploration for barite in North America.

The relatively low cost and technical advantages of barite for the drilling-mud market indicate that other materials will not likely be substituted on a large scale in this major application.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
49205-1	Drilling mud and additives	free	free	free	free
68300-1	Barites	free	10	25	free
92842-1	Barium carbonate	10	15	25	10
92818-1	Barium oxide, hydroxide peroxide	10	15	25	10
93207-5	Lithopone	free	12 1/2	25	free

MFN REDUCTIONS UNDER GATT (effective January 1 of year given)

	1980	1981	1982	1983	1984	1985	1986	1987
				(%)				
92818-1	13.1	11.3	9.4	7.5	5.6	3.8	1.9	free
92842-1	14.7	14.4	14.1	13.8	13.4	13.1	12.8	12.5
93207-5	12.2	11.9	11.6	11.3	10.9	10.6	10.3	10.0

UNITED STATES

Item No.	1980	1981	1982	1983	1984	1985	1986	1987
472.02	Remain free							
472.04	5.8%	5.6%	5.3.%	5.1%	4.9%	4.7%	4.4%	4.2%
	($ per long ton)							
472.10	1.27							
472.12	3.29							
				(¢ per lb)				
472.14	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
473.72	0.43							
473.74	0.43 ¢/lb +3.5%							

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada, Tariff Schedules of the United States Annotated 1980, USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241.

Celestite

Celestite ($SrSO_4$), the main source of strontium, is used to produce commercial strontium compounds, principally strontium carbonate and strontium nitrate. In the sulphate form it is used for purifying electrolytic zinc. Strontium carbonate is primarily used in glass faceplates for colour television picture tubes where it improves the absorption of X-rays emitted by the high voltage tubes. Other uses include pyrotechnics and signals, and ferrite ceramic permanent magnets used in small electric motors. Consumption of strontium in the United States in 1980 was approximately 18 000 t valued at $1.1 million. From a 1978 base, demand for strontium in the U.S. is expected to increase at an annual rate of about 1.4 per cent through 1990, according to the United States Bureau of Mines.

There has been no Canadian production of celestite since Kaiser Celestite Mining Limited, a subsidiary of Kaiser Aluminum & Chemical Canada Investment Limited, closed its mining operation at Loch Lomond, Nova Scotia and its strontium products plant at Point Edward, Nova Scotia, in 1976.

North American consumers continue to depend totally on imports of strontium minerals. The strontium-mining industry in the United States has been dormant since 1959 and Mexico and West Germany are the major suppliers of celestite and strontium compounds to the U.S. market.

PRICES

United States prices of celestite according to **Chemical Marketing Reporter**, December 29, 1980

	($ per short ton)
Strontium carbonate glass grade, bags, carlot, truckload, works	560.00-575.00
	($ per 100 pounds)
Strontium nitrate, bags, carlot, works	24.00

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(%)			
92839-5	Strontium nitrate	free	free	free	free

UNITED STATES, Customs Tariffs (MFN)

Item No.	1980	1981	1982	1983	1984	1985	1986	1987
	(%)							
Strontium metal								
632.46	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
632.68	6.9	6.4	5.8	5.3	4.7	4.1	3.6	3.0
473.17	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
Strontium compounds								
421.70	Remain free							
421.72	5.6	5.6	5.3	5.1	4.9	4.7	4.4	4.2
421.74	5.8	5.6	5.3	5.1	4.9	4.7	4.4	4.2
421.76	5.8	5.6	5.3	5.1	4.9	4.7	4.4	4.2
421.82	Remain free							
421.84	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
421.86	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated 1980, USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241.

Bentonite

G.O. VAGT

Bentonite is a clay of varied chemical composition consisting primarily of the mineral montmorillonite a member of the smectite group of clay minerals. "Smectite", as a group name, replaces confusing terminology that includes "montmorillonite" as both mineral species and group names.

Bentonite may originate from smectitic clays formed from volcanic ash, tuff or glass, other igneous rocks, or from rocks of sedimentary or uncertain origin. The deposits occur in relatively flat-lying beds of various chemical compositions and impurities; the latter consisting of quartz, chlorite, biotite, feldspar, pyroxenes, zircon and various other minerals. Natural clay may be creamy white, grey, blue, green or brown; and, in places, beds of a distinctly different colour are adjacent. Fresh, moist surfaces are waxy in appearance; on drying, the colour lightens, and the clay has a distinctive cracked or crumbly texture.

Montmorillonite is a hydrated aluminum silicate with weakly-attached cations of sodium and calcium which impart different properties to bentonite depending on amounts and proportions present. One method of classifying bentonite is based on its swelling capacity when wet. With sodium as the dominant or abundant exchangeable ion, swelling of about 10 times the original dry volume will occur, and when added to water, gel-like masses result. Sodium bentonite also possesses a high dry-bonding strength, especially at high temperatures, a feature important in the pelletizing of iron ores and in the manufacture of some ceramic products.

Monmorillonite clays have ion-exchange properties and, by adsorption, absorption and chemical activity, bentonite can collect many types of inorganic and organic compounds, sometimes selectively. In general, the non-swelling or calcium bentonites exhibit the more pronounced adsorptive characteristics. While naturally-occurring clays may exhibit adsorptive or bleaching properties, their efficiencies are commonly improved by acid leaching or, as the process is generally termed, activation.

Another clay, "fuller's earth", also contains mainly smectite-group clay minerals and is very similar to non-swelling bentonite. These clays are non-plastic, usually high in magnesia and have natural bleaching and absorbent properties allowing their use for decolourizing and purifying. The terminology is confusing, and bentonite and fuller's earth may or may not be separated in world trade and production figures by country.

Known Canadian bentonite occurrences are confined to Cretaceous and Tertiary rocks at many localities in Manitoba, Saskatchewan, Alberta and British Columbia. Although clay beds occur in rocks older than Cretaceous in Canada, none of these has been identified as bentonite.

PRODUCTION IN CANADA

Three companies presently mine and process bentonite in Canada. Statistics on total production and exports are not available for publication.

Pembina Mountain Clays Incorporation mines non-swelling bentonite from the Upper Cretaceous Vermillion River Formation, 30 km northwest of Morden, Manitoba, which is 130 km southwest of Winnipeg. Some bentonite is dried and pulverized in a plant at Morden, but the bulk of production is railed from Morden to the company's activation plant at Winnipeg, where it is leached, washed, filtered, dried, pulverized and bagged. The main use is for decolourizing and purifying mineral and vegetable oils, animal fats and tallows. Highly sorptive properties also make this bentonite suitable for pet litter and floor sweeping compounds. Control of Pembina was acquired in 1979 by Filtrol Corporation, controlled in turn by United States Filter Corporation of New York. Plant expansions to increase output and to develop a more complete range of products for the domestic and export markets have been undertaken.

In Saskatchewan, Avonlea Mineral Industries Ltd. operate a bentonite processing plant in Wilcox, approximately 30 km south of Regina. Raw material is transported a distance of approximately 20

TABLE 1. CANADA, BENTONITE IMPORTS AND CONSUMPTION, 1979 AND 1980

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Imports				
Bentonite				
United States	423 902	15,703,000	342 951	12,856,000
Greece	188 772	5,130.000	125 929	5,038,000
Other countries	72	32,000	412	117,000
Total	612 746	20,865,000	469 292	18,011,000
Activated clays and earths				
United States	14 031	6,281,000	16 239	7,722,000
France	826	626,000	1,099	917,000
West Germany	169	156,000	216	261,000
Total	15 026	7,063,000	17 554	8,900,000
Fuller's earth				
United States	1 483	156,000	1 385	169,000
Consumption[1] (available data)		1977	1978	1979P
			(tonnes)	
Pelletizing iron ore		256 066	183 290	265 213
Foundries		58 297	54 691	51 125
Well drilling		22 685	19 820	18 051
Fertilizer stock and poultry feed		1 578	1 059	806
Paint and varnish		166	142	197
Chemicals		180	146	63
Other products[2]		1 419	1 953	4 451
Total		340 391	261 101	339 906

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Does not include activated clays and earths or fuller's earth. Breakdown by Mineral Policy Sector, Energy, Mines and Resources Canada. [2] Refractory brick and mixes, rubber products, ceramic products and other miscellaneous minor uses.

P Preliminary.

km to the 50 000 tpy plant. Major uses of the final product are as a binder in foundry sands, for reservoir sealing, oilwell drilling mud, and for iron ore pelletizing.

In Alberta, Dresser Minerals Division of Dresser Industries, Inc., recovers swelling bentonite from the Edmonton Formation of Upper Cretaceous age. The deposits are in the Battle River Valley, 14 km south of Rosalind, the site of the company's processing plant. The bentonite is mined selectively from relatively shallow paddocks or pits in the dry summer months. Some natural drying may be done by spreading and harrowing material before trucking it to the plant for drying, pulverizing and bagging. Bentonite, of intermediate swelling quality, from Alberta, may be used as a foundry clay, as a sealer for farm reservoirs, as feed pelletizing material, as a drilling-mud additive, as an additive to water for fire fighting and as a soil stabilizer.

USES, CONSUMPTION AND TRADE

Bentonite, as well as having many uses alone, is used in the manufacture of many products, where it generally constitutes only a small part of the final product.

Select swelling bentonite has found widespread and rapidly growing use as a binder in the pelletizing of iron ore concentrates. Nearly 80 per cent of the reported total consumption of bentonite in Canada in 1979 was used for this purpose. About 18 pounds is used in every long ton of concentrate to provide pellets with sufficient "green" strength to withstand handling during the drying and firing stages. The amount of bentonite required varies with the mineralogy and particle size of the concentrate. The large volume requirements of individual pelletizing plants has tended to result in more emphasis on low cost and availability rather than on higher cost material with stringent specifications.

Special muds used in oil- and gas-well drilling contain about 10 per cent swelling bentonite, which is used principally to prevent the loss of drilling fluid into permeable zones by forming a mud cake on the wall of the drill hole. Of equal importance, swelling bentonite acts as a suspension agent to carry drill cuttings in water-based muds to the surface. Synthetic bentonite (sodium-exchanged calcium bentonites) may also be used in special muds, depending upon the cost and availability of natural swelling bentonites.

Swelling bentonite serves as a binder in moulding sands used by iron and steel foundries. For blending purposes the use of non-swelling bentonite is also important.

Swelling bentonite is also used as a binder in stock feeds. Small quantities are used as a plasticizer in abrasive and ceramic mixes and as a filler in paints, paper, rubber, pesticides, cosmetics, medicinal products, and cleaning and polishing compounds. Engineering applications are: in grout for sealing subsurface water-bearing zones, dams and reservoirs; as additives to cements, mortars and concretes to suppress bleeding of the mixing water; as a compacting agent for gravels and soils; and as a ground stabilizing medium for excavations when used in a bentonite-water suspension. Bentonite slurry is also effective in fighting forest fires.

Some non-swelling bentonite is used in pelletizing stock feed, as a carrier and diluent for pesticides, and as a cleaning powder for animals.

TABLE 2. CANADA, BENTONITE IMPORTS[1] AND CONSUMPTION[2], 1970, and 1975-80

	Imports (tonnes)	Imports ($)	Consumption (tonnes)
1970	351 066	5,590,000	285 671
1975	287 886	9,388,000	286 109
1976	367 162	10,244,000	335 553
1977	481 213	13,757,000	346 698
1978	309 253	12,468,000	264 894
1979	629 255	28,084,000	345 083
1980P	488 231	27,080,000	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Includes bentonite, fuller's earth and activated clays and earths. [2] Includes only fuller's earth and bentonite.

P Preliminary; .. Not available.

Activated bentonite is used in decolouring mineral and vegetable oils, animal fats, waxes, beverages and syrups. It is also used in some countries as a catalyst in the refining of fluid hydrocarbons. Quantaties of activated clays and fuller's earth are imported mainly from the United States. Some activated bentonite from Manitoba is exported to the United States.

The average level of bentonite consumption in Canada increased substantially during the last decade, largely because of increased consumption as a binder in iron concentrate pelletizing, as more of these plants have been constructed. Consumption of bentonite in the oil and gas industry is subject to considerable fluctuation that is not necessarily directly related to the footage drilled. Factors such as age and degree of compaction of the rock formations encountered as well as the severity of subsurface geopressures and temperatures that vary from region to region are also important determinants.

Bentonite production in the United States is about 4.4 million tpy with approximately 75 per cent from extensive deposits in Wyoming where the name was derived from the Cretaceous Fort Benton Formation. These Cretaceous deposits are the world's most outstanding swelling bentonite occurrences and the specifications and standards for bentonite used in industry are based on these high-quality clays. Although there are numerous occurrences of bentonite in many countries it is mined in only a few. In recent years, Wyoming producers have lost some markets for iron ore pelletizing in eastern Canada to Greek bentonite producers. The cost spread between rail and ocean transportation is the principal reason for this change. Canada is by far the main importer from the United States, which also ships some bentonite to numerous countries throughout the world. Baroid Petroleum Services division of N L Industries, Inc. announced construction of bentonite drying and grinding facility near Lovell, Wyoming. The consumption of pelletizing and foundry grades fell in 1980, however the growth in bentonite demand for drilling fluids is expected to be especially strong throughout the 1980s.

A variety of fuller's earth, mainly comprising attapulgite, a lath-shaped amphibole clay mineral, was produced primarily in Florida and Georgia. Additional types of fuller's earth, mainly comprising montmorillonite, were produced in seven other states.

OUTLOOK

Demand for pelletizing grade bentonite is not expected to increase because the iron ore industry is forecast to remain in a surplus capacity situation until about 1985. Improved characterizing and mixing of bentonite for pelletizing have been identified as important elements of a minerals research program in Canada. Transportation costs to distant pelletizing plants often add considerably to the cost of natural swelling Wyoming bentonite which for many years was specified as the bonding agent for thermally processed iron ore pellets. For this reason, more attention will be directed toward finding closer or otherwise less expensive sources of natural bentonite or toward the use of soda-activated bentonites.

It is expected that bentonite consumption in Canada will continue to hold its own relative to substitute binders. Although increasing emphasis is being placed on the direct reduction (DR) process for steel production, the tonnage processed by DR methods will remain a small proportion of the total for many years. Recessionary conditions may result in cutbacks in the production of iron-ore pellets by major Quebec producers. Also, closure of small Ontario iron ore producers in 1979 and 1980 will tend to decrease overall demand for bentonite.

PRICES

United States bentonite prices according to **Chemical Marketing Reporter**, December 29, 1980

	$
Bentonite, domestic, bulk, carlots, fob mines West Coast, per short ton	27.10

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
29500-1	Clays, not further manufactured than ground	free	free	free	free
93803-2	Activated clay	10%	14.7%	25%	10%
20600-1	Fuller's earth, in bulk	free	free	free	

MFN Reductions under GATT (effective January 1 of year given)

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
93803-2	Activated clay	14.7	14.4	14.1	13.8	13.4	13.1	12.8	12.5

UNITED STATES

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
					(per long ton)				
521.61	Bentonite	40¢)							
521.51	Fuller's earth - not beneficiated	25¢)	Remains the same						
521.54	Fuller's earth, bulk	50¢)							
				(cents per lb + % ad valorem)					
521.87	Clays, artificially activated etc.	0.04¢ 5.6%	0.04¢ 5.1%	0.03¢ 4.7%	0.02¢ 4.3%	0.02¢ 3.8%	0.01¢ 3.4%	0.01¢ 2.9%	- 2.5%

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada. Tariff Schedules of the United States Annotated 1980, USITC Publication 1011. U.S. Federal Register Vol. 44, No. 241.

Bismuth

J.J. HOGAN

Bismuth is obtained in Canada from the processing of certain base-metal ores. The more important sources are the lead-zinc-copper ores mined in New Brunswick and the lead-zinc ores mined in southeastern British Columbia. Smaller amounts have been recovered in the past from ores mined in Ontario and Quebec, and the silver ores of Great Bear Lake, Northwest Territories.

Bismuth production in Canada in 1980, based on bismuth recovered from domestic ores and concentrates, is estimated to be 171 000 kilograms (kg) valued at $1,269,000 compared with 136 733 kg in 1979 valued at $973,979. The 25 per cent increase in 1980 was attributed mainly to Brunswick Mining and Smelting Corporation Limited, whose mine was closed by a lengthy strike in 1979. Inventories of metallic bismuth held by Canadian consumers as of December 31, 1979 totalled 2 945 kg but figures on the end-1980 total are not available.

World production of bismuth in 1980, as estimated by the United States Bureau of Mines but excluding United States production, was 3 663 700 kg compared with 4 229 044 kg in 1979. A near halt in Bolivian production, which accounted for about 11 per cent of world output in 1979 but less than one per cent in 1980, was largely responsible for the sharp drop in 1980 world production. Australia maintained its position as the world's largest producer, accounting for about 25 per cent of the world's total. Other major producers were Mexico, Japan and Peru. The above four countries accounted for about 77 per cent of the world's output in 1980.

DOMESTIC SOURCES

The Smelting Division of Brunswick Mining and Smelting has facilities to produce bismuth metal and alloys at its Belledune lead smelter, about 40 kilometres (km) northwest of Bathurst, New Brunswick, but at present is producing only a bismuth alloy. In 1980 construction of a bismuth crystal plant was completed. The plant produces a crystal alloy which contains 45 per cent bismuth, 45 per cent lead and 10 per cent combined calcium and magnesium, and is exported for the recovery of bismuth and lead.

Primary bismuth metal is produced by Cominco Ltd. at its lead-zinc plant in Trail, British Columbia. Cominco derives most of its Canadian output from lead concentrates produced at its Sullivan lead-zinc mine at Kimberley. Other sources include lead concentrates from other company mines and domestic shippers and a significant amount from foreign custom shippers. Lead bullion produced from the smelting of these concentrates contains about 0.05 per cent bismuth. The metal is recovered as 99.99+ per cent metal from the treatment of residues resulting from the electrolytic refining of lead bullion. Production in 1980 totalled 91 375 kg compared with 122 928 kg in 1979.

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Some bismuth is further processed at Cominco's nearby high purity plant to give it a purity of up to 99.9999 per cent for use in research and in the electronics industry.

Bismuth occurs in the multi-mineral deposit of Brunswick Tin Mines Limited located about 64 km north of St. Andrews, New Brunswick. The property is being brought into production by Brunswick Tin Mines and Billiton Canada Ltd., under a joint venture arrangement (Mount Pleasant Joint Venture), but initially only the tungsten and molybdenum will be recovered.

WORLD DEVELOPMENTS

The general slowdown in the world's business activity in 1980 had its affect on the bismuth industry. Both the producer and dealer prices declined sharply and in October ASARCO Incorporated, the only primary bismuth producer in the United States, withdrew its formal producer price.

Peko-Wallsend Ltd., a major Australian producer of bismuth, operated the Warrego and Gecko copper-gold-bismuth mines in the Tennant Creek area, Northern Territory and a copper smelter at Mount Morgan, Queensland. Assessment of the ore deposit at Warrego continued throughout the year. The Gecko mine came on-stream in 1980. Exploration and development at this mine has been successful in adding to reserves. Bismuth contained in the Tennant Creek ores creates problems in the copper smelting process and it is necessary to remove it. Part of the bismuth is recovered by the production of a bismuth flotation concentrate. The remainder is recovered in the flue dusts from the smelting of the copper concentrates. Stage I of a two stage bismuth plant is being constructed at Tennant Creek. It is expected to be in operation in late 1980 or early 1981 and will recover the copper and gold contained in the concentrates and furnace dusts. The bismuth residue remaining will be stockpiled until bismuth demand and price warrant the construction of a second stage plant to produce bismuth metal.

The extension to the lead refinery of The Broken Hill Associated Smelters Pty Ltd. at Port Pirie, South Australia, which includes a plant to upgrade the quality of lead metal by removing bismuth, was

TABLE 1. CANADA, BISMUTH PRODUCTION AND CONSUMPTION, 1979 AND 1980

	1979		1980P	
	(kilograms)	($)	(kilograms)	($)
Production, all forms[1]				
New Brunswick	102 925	800,312	135 000	1,002,000
British Columbia	33 808	173,667	36 000	267,000
Total	136 733	973,979	171 000	1,269,000

	1979 (kilograms)	1980 (kilograms)
Consumption, refined metal (available data)		
Fusible alloys	6 787	..
Other uses	18 390	..
Total	25 177	20 764

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Refined bismuth metal from Canadian ores, plus recoverable bismuth content of bullion and concentrates exported.

P Preliminary; .. Not available.

TABLE 2. CANADA, BISMUTH PRODUCTION AND CONSUMPTION, 1970, 1975-80

	Production all forms[1]	Consumption[2]
	(kilograms)	
1970	267 774	11 135
1975	156 605	29 267
1976	129 578	21 105
1977	164 685	25 016
1978	145 104	25 665
1979	136 733	25 177
1980[P]	171 000	20 764

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Refined bismuth metal from Canadian ores, plus recoverable bismuth content of bullion and concentrates exported. [2] Refined bismuth metal reported by consumers.
[P] Preliminary.

completed in 1980. The bismuth content of the lead-zinc ores in the Broken Hill area, New South Wales, which are treated at the Port Pirie smelter, has recently been increasing.

Bolivia is one of the countries where the bismuth content of some ores is high enough to be mined primarily for bismuth. Bolivian mines can therefore adjust output to meet market demand and in 1980 substantially lowered their production. The state-owned company, Corporacion Minera de Bolivia (COMIBOL) suspended bismuth production in early 1980 pending an improvement in the price and demand for the metal. Most of Bolivia's bismuth output comes from four state-owned mines in the Quechisla group, located in southern Bolivia. COMIBOL operates the country's sole bismuth smelter at Telemaya, about 100 km north of Quechisla. The smelter can treat about 4 800 tonnes (t) of concentrates, equivalent to about 800 tpy of bismuth metal. COMIBOL also operates the country's sole bismuth metal refinery at Quechisla with an annual capacity of 650 t of 99.99 per cent bismuth. In the past Bolivia exported bismuth contained in ores and concentrates. It was also reported that Bolivia shipped about 450 t of bismuth from its stockpile to the U.S.S.R. in 1980.

TABLE 3. WORLD MINE PRODUCTION OF BISMUTH, 1978-80

	1978	1979[P]	1980[e]
		(kilograms)	
Australia	929 864	952 544	907 200
Mexico[1]	977 945	680 389	680 400
Japan	614 618	635 029	635 000
Peru[1]	589 670[e]	635 029	589 700
Bolivia[2]	482 169	453 592	22 700
People's Republic of China[e]	299 371	299 371	..
Canada	145 104	136 733	171 000
Republic of Korea	122 016	181 437	113 400
Romania[e]	81 647	81 647	..
U.S.S.R.[e]	68 039	72 575	..
France	58 967[e]	45 359	..
Yugoslavia	13 154	28 123	..
Other countries	24 948	27 216	544 300
Total[3]	4 407 512	4 229 044	3 663 700

Sources: Statistics Canada; Energy, Mines and Resources Canada. For other countries for 1978 and 1979 U.S. Bureau of Mines, Minerals Yearbook Bismuth Preprint, 1978-79. For other countries for 1980, U.S. Bureau of Mines, Mineral Commodity Summaries, 1981.
[1] Bismuth content of refined metal, bullion and alloys produced indigenously, plus recoverable bismuth content of ores and concentrates exported for processing. [2] Production by Corporacion Minera de Bolivia (COMIBOL) plus exports by medium and small mines. [3] Total for listed figures only; it excludes United States production, which is not available for publication, as well as that of some other smaller producing countries.
[e] Estimated; [P] Preliminary; .. Not available, but estimate included in figure for "Other countries".

Refined bismuth metal in Peru is produced as a byproduct of lead ores at the La Oroya smelting and refining complex of Empresa Minera del Peru (Centromin).

In the United States, consumption of bismuth in 1980 was 1 038 185 kg, about 16 per cent lower than the 1 237 016 kg consumed in 1979. The pharmaceutical industry continued to be the largest consumer of bismuth, accounting for 506 034 kg or 48.7 per cent of the 1980 total compared with 566 381 kg in 1979. The other two major uses of bismuth are in fusible alloys and metallurgical additives, the former accounting for 28.4 per cent of the total and the latter 20 per cent. Bismuth used in fusible alloys was 295 241 kg, 9.7 per cent lower than in 1979. Bismuth used in metallurgical additives was 212 254 kg, 33.5 per cent lower than the 319 225 used in 1979 but only slightly lower than the 220 121 kg used in 1978. The stockpile goal established by the US Federal Preparedness Agency for bismuth was increased to 997 903 kg in 1980 from 349 720 kg. At the end of 1980 the stockpile contained 943 926 kg, a shortage of 53 977 kg.

USES

Major uses of bismuth are in pharmaceuticals, cosmetics and industrial and laboratory chemicals, including catalytic compounds. Various bismuth compounds, salts and mixtures are used in pharmaceuticals for indigestion remedies, antacids, and burn and wound dressings. The consumption of bismuth for indigestion remedies is on the decline since France made such compounds a prescription drug item. France is the leading consumer in this category. Insoluble salts of bismuth are given to patients before X-ray examination of the digestive tract. Cosmetics containing bismuth oxychloride, which imparts a "pearlescent" glow to eye shadow, lipstick, nail polish and powders, comprise one of the larger end-use markets of bismuth, but consumption in this market depends on changing fashion trends and is declining.

TABLE 4. UNITED STATES CONSUMPTION OF BISMUTH BY PRINCIPAL USES, 1979 AND 1980

	1979	1980P[1]
	(kilograms, bismuth content)	
Pharmaceuticals[2]	566 381	556 826
Metallurgical additives	319 225	212 409
Fusible alloys	327 060	291 399
Other alloys	9 992	11 996
Experimental uses	1 430	380
Other uses	12 928	7 257e
Total	1 237 016	1 080 347

Source: U.S. Bureau of Mines, Mineral Industry Surveys, "Bismuth in the Fourth Quarter 1980".

[1] Estimated 100 per cent coverage based on reports from respondents that consumed 87 per cent of the total bismuth metal in 1979.

[2] Includes industrial and laboratory chemicals.

P Preliminary; e Estimated.

Another important outlet for the metal is fusible or low-melting point alloys for fire-protection devices, electrical fuses, fusible plugs and solders. Many of these alloys contain 50 per cent or more bismuth with the chief additive metals being cadmium, lead and tin. In safety applications, the dependability of the melting temperatures of the various bismuth alloy compositions is of utmost importance. Pure bismuth metal expands 3.3 per cent on changing from a molten to a solid state. Nonshrinking, low-melting point bismuth alloys are used in the holding of jet engine airfoil blades during the machining of the root sections. Bismuth-tin alloys are sprayed on patterns to make moulds in the plastic industry. With indium, bismuth forms a low-melting alloy used in ophthalmic industry for holding lenses. An important use of bismuth is as an additive to aluminum alloys, malleable irons and steel alloys to improve machinability. In 1980 Inland Steel Company of Chicago introduced a new free-machining bismuth steel alloy to supplant the traditional tellurium-lead steel alloys which could create environmental problems.

The United States Atomic Energy Commission uses bismuth in many nuclear research applications because of the metal's low thermal neutron absorption rate.

Bismuth is used in catalysts in the production of acrylonitrile for acrylic fibres and plastics. This use suffered some decline in the 1960s but technological improvements in the process led to increased demand in the 1970s. The rubber industry also uses a bismuth compound to accelerate the vulcanisation process.

PRICES

The Canadian price for 99.994 per cent pure bismuth metal in 1980, as quoted by Cominco

Ltd., was $3.50 per pound for the period January to September 8 and $3 per pound for the balance of the year.

The United States domestic producer price for 99.99 per cent pure bismuth in 1980, as quoted in **Metals Week**, was $3 per pound for the period January to early August at which time the price was lowered to $2.50 per pound. On October 1, ASARCO, the only producer in the United States, stopped publishing its bismuth producer price. The average United States producer price for 1980 as reported by **Metals Week** was $2.637 per pound.

The dealer price for bismuth on the New York Market opened the year at $2.50 to $2.60 per pound and had a slight upward flurry in late January and early February on reported speculative activity by traders and tight supply for prompt delivery. The upward trend was short lived and the bismuth dealer price decline steadily during the year, closing at $2.00 to $2.10 per pound.

OUTLOOK

No marked changes are expected in the bismuth market in 1981. Stocks on hand plus 1981 production should meet normal demand. Wide acceptance of the new bismuth alloy steel developed by Inland Steel could substantially increase as the market is developed. No supply problems are envisaged in the medium to long term. Bolivia has suspended bismuth production until the price strengthens, but since bismuth production comes from mines that are worked primarily for their bismuth content, Bolivian bismuth production can be restored in a relatively short period. Australia can also increase its bismuth output when the price improves.

TARIFFS

CANADA

Item No.		British Preferential	General Preferential	Most Favoured Nation	General
33100-1	Bismuth ores and concentrates	free	free	free	free
35106-1	Bismuth metal, not including alloys, in lumps, powders, ingots or blocks	free	free	free	25%

UNITED STATES (MFN)

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
601.66	Bismuth ores and concentrates		free						
632.10	Bismuth metal unwrought, etc.		free						
632.64	Alloys of bismuth etc.		free						
632.66	Other alloys of bismuth	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5
633.00	Bismuth metal wrought	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated 1980, USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241.

Cadmium

M.J. Gauvin

Cadmium is a relatively rare element in the earth's crust, occurring most commonly as the sulphide, greenockite (CdS) which is found associated with zinc sulphide ores, particularly sphalerite ((Zn, Fe)S). There are no known commercial orebodies of cadmium; reserves at any time are a function of zinc reserves and specifically the cadmium content of those reserves.

Cadmium metal is recovered as a by-product of zinc smelting and refining. Since secondary sources are considered negligible in terms of total supply, cadmium production is a function of zinc metal production which bears little or no relationship to the demand for cadmium. Canadian production in the past five years has ranged from 2.2 to 2.9 kilograms for each tonne (t) of zinc metal produced.

PRODUCTION AND CONSUMPTION

Canada is the non-socialist world's fourth largest producer of cadmium metal following Japan, the United States and Belgium. Canadian production of refined cadmium in 1980 was 1 303 t compared with 1 455 t in 1979. Production of cadmium in the non-socialist world, as reported by the World Bureau of Metal Statistics, decreased in 1980 to an estimated 13 753 t from 14 600 t in 1979.

Consumption of refined cadmium in Canada as reported by consumers to Statistics Canada was 48.7 t in 1979 compared with 47.5 t in 1978. Domestic shipments as reported by producers was 88 t in 1980, 121 t in 1979 and 142 t in 1978. Consumption of cadmium as indicated by producer shipments was lower than in 1979, mainly because of the economic downturn that led to lower automobile and plastics production.

TABLE 1. CANADIAN PRIMARY CADMIUM STATISTICS, 1978-80

	1978	1979	1980P
		(tonnes)	
Metal production	1 265	1 455	1 303
Metal capacity	1 705	1 705	1 705
Metal shipments:			
Domestic	142	121	88
Exports	1 259	1 293	1 096

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary.

USES

Cadmium is a soft, ductile, silver-white electropositive metal. It is used for electroplating iron and steel products to protect them against oxidation. A cadmium coating, like a zinc coating, protects metals that are lower in the electromotive series by physical enclosure and by sacrificial corrosion, and this is the largest use for cadmium. Cadmium-plated parts are used in automobiles, household appliances, aircraft, radios, television sets and electrical equipment.

The second-largest use according to the Statistics Canada survey is in the manufacture of pigments and chemicals. Cadmium sulphides give yellow-to-orange colours and cadmium sulphoselenides give pink-to-red and maroon. Cadmium is a valuable alloying metal and has applications in cadmium-silver solders and in cadmium-tin-lead-bismuth fusible or low-melting-point alloys for automatic sprinkler systems, fire-detection apparatus and valve seats for high-pressure gas containers. A growing application is in the production of nickel-cadmium storage batteries. These batteries are considerably more expensive than the standard lead-acid battery, but have a longer life and higher peak-power output, are smaller and are superior in low-temperature operation.

PRICES

The United States producer price as reported by **Metals Week** was $US 3.15 a pound at the beginning of the year and increased to $3.25 at the end of January. In late April the price was adjusted to $3.00 and in July it was lowered to $2.50 a pound, which price was maintained to the end of the year. In Canada the producer price was $3.38 from the beginning of the year until late June when it was reduced to $3.00 a pound. This price was quoted throughout the balance of the year.

TABLE 2. CANADA, CADMIUM METAL CAPACITY, 1980

Company and Location	Annual Capacity (tonnes)
Canadian Electolytic Zinc Limited Valleyfield, Quebec	544
Cominco Ltd. Trail, British Columbia	544
Hudson Bay Mining and Smelting Co., Limited Flin Flon, Manitoba	163
Texasgulf Canada Ltd. Timmins, Ontario	454
Total Canada	1 705

Source: Operators List No. 3, **Metallurgical Works in Canada, Nonferrous and Precious Metals**, January 1977, Department of Energy, Mines and Resources, Canada.

TABLE 3. CANADA, CADMIUM PRODUCTION AND EXPORTS 1979 AND 1980, AND CONSUMPTION 1978 AND 1979

	1979		1980P	
	(kilograms)	($)	(kilograms)	($)
Production				
All forms[1]				
Ontario	672 837	4,795,677	665 000	4,919,000
British Columbia	239 096	1,704,169	159 000	1,177,000
Quebec	185 427	1,321,638	139 000	1,029,000
Newfoundland	69 821	497,652	55 000	406,000
Manitoba	33 614	239,588	30 000	219,000
Saskatchewan	8 664	61,754	5 000	40,000
Total	1 209 459	8,620,478	1 053 000	7,790 000
Refined[2]	1 454 954	..	1 302 955	..
Exports				
Cadmium metal				
United States	720 955	4,082,000	782 935	4,951,000
United Kingdom	561 363	3,230,000	312 418	1,904,000
Israel	-	-	34	21,000
Netherlands	9 997	42,000	21	9,000
West Germany	-	-	11	6,000
Greece	200	1,000	399	4,000
Total	1 292 515	7,355,000	1 095 818	6,895,000

TABLE 3 (cont'd)

	1978	1979
	(kilograms)	
Consumption		
Cadmium metal[3]		
Plating	19 319	24 558
Solders	4 368	6 568
Other uses[4]	23 836	17 620
Total	47 523	48 746

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Production of refined cadmium from domestic ores, plus recoverable cadmium content of ores and concentrates exported. [2] Refined metal from all sources and cadmium sponge. [3] Available data reported by consumers. [4] Mainly chemicals, pigments and alloys other than solder.
P Preliminary; - Nil; .. Not available.

TABLE 4. CANADA, CADMIUM PRODUCTION, EXPORTS AND DOMESTIC SHIPMENTS, 1970, 1975-80

	Production		Exports	Producers'
	All Forms[1]	Refined[2]	Cadmium Metal	Domestic Shipments
	(kilograms)			
1970	1 954 055	836 745	702 630	157 307
1975	1 191 674	1 142 508	637 797	98 820
1976	1 313 723	1 387 805	1 555 772	135 354
1977	1 185 446	1 369 447	869 684ʳ	84 944
1978	1 151 298	1 264 804	1 259 290	141 579
1979	1 209 459	1 454 954	1 292 515	120 926
1980P	1 053 000	1 302 955	1 095 818	88 232

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Production of refined cadmium from domestic ores plus recoverable cadmium content of ores and concentrates exported. [2] Refined metal from all sources and cadmium sponge.
P Preliminary; ʳ Revised.

TABLE 5. CADMIUM METAL PRICES, 1980

	Northern Miner	Metals Week		Metal Bulletin	
Month	Cominco	U.S. Producer	New York Dealer	Commonwealth Producer	European free market, sticks
	($Cdn/lb)	($US/lb)		($US/lb)	
January	3.38	3.152	2.850-3.180	3.00	2.934-3.081
February	3.38	3.250	2.850-3.200	3.00	2.822-2.950
March	3.38	3.250	2.930-3.050	3.00	2.881-3.013
April	3.38	3.193	2.500-3.030	3.00	2.600-2.794
May	3.38	3.000	2.150-2.550	3.00	2.117-2.283
June	3.25	3.000	2.250-2.500	3.00	2.194-2.344
July	3.00	2.773	2.250-2.400	3.00	2.128-2.222
August	3.00	2.500	2.250-2.450	3.00	2.158-2.258

TABLE 5 (cont'd)

Month	Northern Miner	Metals Week		Metal Bulletin	
	Cominco	U.S. Producer	New York Dealer	Commonwealth Producer	European free market, sticks
	($Cdn/lb)	($US/lb)		($US/lb)	
September	3.00	2.500	2.300-2.450	3.00	2.200-2.284
October	3.00	2.500	2.300-2.400	3.00	2.157-2.246
November	3.00	2.500	2.180-2.400	3.00	2.038-2.124
December	3.00	2.500	2.000-2.250	3.00	1.818-1.939
Average 1980	3.18	2.843	2.401-2.655	3.00	2.337-2.462

Sources: **Northern Miner, Metals Week, Metal Bulletin.**

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
32900-1	Cadmium in ores and concentrates	free	free	free	free
35102-1	Cadmium metal, not including alloys, in lumps, powders, ingots, or blocks	free	free	25	free

UNITED STATES

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
601.66	Cadmium in ores and concentrates	Remains free							
632.14	Cadmium metal, unwrought, waste and scrap	Remains free							
632.86	Cadmium alloys, unwrought containing by weight 96% or more but less than 99% of silicon	9.0			- no change -				9.0
632.88	Cadmium alloys, unwrought, other	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5
633.00	Cadmium metal, wrought	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5

EUROPEAN ECONOMIC COMMUNITY (MFN)

Item No.		1980	Base Rate	Concession Rate
			(%)	
26.01	Cadmium in ores and concentrates	free	free	free
81.04	Cadmium metal, unwrought, waste and scrap	4	4	4
	Cadmium metal, other	6	6	6

TARIFFS (cont'd)

JAPAN (MFN)

Item No.		1980	Base Rate	Concession Rate
			(%)	
26.01	Cadmium in ores and concentrates	free	free	free
81.04	Cadmium metal:			
	Unwrought	7.3	10	5.1
	Waste and scrap	7.2	10	4.8
	Powders and flakes	7.5	10	5.8
	Cadmium metal, other	10.6	15	6.5

Sources: The Customs Tariff and Commodities Index, January, 1980. Revenue Canada; Tariff Schedules of the United States Annotated (1980), USITC Publication 1011; U.S. Federal Register, Vol. 44, No. 241; Official Journal of the European Communities, Vol. 22, No. L342, 1979; Customs Tariff Schedules of Japan, 1979; GATT Documents, 1979.

Cement

D.H. STONEHOUSE

THE CANADIAN INDUSTRY IN 1980

Over the past few years performance of the Canadian portland cement industry has been buoyed up considerably by a healthy export market for both cement and clinker in the United States. Despite projections of a major recession and attendant reduction in construction spending, shipments from Canadian portland cement producers to Michigan, New York, Vermont and Washington states reached record proportions in 1979. When the crunch finally came in early 1980 it was more widespread and more severe than anticipated. This, together with poor activity in the Canadian construction industry, resulted in shipments of cement and clinker being reduced by about 12 per cent in 1980. For the first time in many years some plants stopped producing clinker for a number of weeks while inventories were reduced.

In Canada the effects of a depressed housing market were offset slightly by increases in the nonresidential sector. Engineering construction has normally accounted for 40 per cent of total construction expenditures while building construction constituted the larger portion. A prediction that, with new projects relating to energy, environmental control and transportation, engineering construction would rise to a 50 per cent share of the total value of construction during the 1980s, seems to be on track as in 1980 engineering construction represented 44 per cent of total value.

Markets for cement were slow in the Atlantic region, down as compared to 1979 in Quebec and Ontario, down in Manitoba and Saskatchewan, little changed in Alberta and up significantly in British Columbia. Cement and clinker were again shipped from Quebec and Ontario to Alberta, principally to offset lost production resulting from strike action at the Winnipeg and Exshaw plants of Canada Cement Lafarge Ltd. (CCL). By August 1980 the company's two Ontario plants at Woodstock and Bath were also struck. The company's expansion program at Exshaw was set back as a result of this action.

CCL exported cement to Florida from Nova Scotia during the year through Halifax. The company converted its Birmingham, Alabama plant to a distribution centre in mid-year, contending it could supply customers from its new Demopolis, Alabama, plant. Both plants are owned by CCL's subsidiary, Citadel Cement Corporation, which, toward the end of the year, reached an agreement in principle to purchase a New Orleans plant from Lone Star Industries, Inc. for about $US 13 million.

The trend of a few years toward direct involvement of Canadian cement producers in the production of cement in the United States from clinker brought in from their Canadian plants, or to the establishment of distribution terminals in the United States at purchased plant sites, has had similar results for most companies, as the U.S. markets finally soured in 1980. St. Lawrence

TABLE 1. CANADA, CEMENT PRODUCTION AND TRADE, 1979 AND 1980

	1979		1980p	
	(tonnes)	($)	(tonnes)	($)
Production[1]				
By province				
Ontario	4 804 775	222,966,000	4 283 000	225,594,000
Quebec	2 551 891	132,952,000	2 278 000	134,708,000
Alberta	1 336 320	97,482,000	1 197 000	99,088,000
British Columbia	1 406 677	86,900,000	1 258 000	83,457,000
Manitoba	637 684	45,530,000	567 000	45,940,000
Saskatchewan	341 549	30,524,000	304 000	30,881,000
Nova Scotia	..	17,238,000	..	17,280,000
New Brunswick	..	13,501,000	..	14,002,000
Newfoundland	..	6,784,000	..	6,452,000
Total	11 765 248	653,877,000	10 497 000	657,402,000
By type				
Portland	11 391 140	..	10 161 000	..
Masonry[2]	374 108	..	336 000	..
Total	11 765 248	653,877,000	10 497 000	657,402,000
Exports				
Portland cement				
United States	2 288 655	94,991,000	1 451 863	62,266,000
Saudi Arabia	17	1,000	68 947	2,472,000
U.S. Oceania	-	-	5 169	205,000
Other countries	150	15,000	1 529	123,000
Total	2 288 822	95,007,000	1 527 508	65,066,000
Cement and concrete basic products				
United States	..	61,501,000	..	37,997,000
Other countries	..	753,000	..	2,008,000
Total	..	62,254,000	..	40,005,000
Imports				
Portland cement, standard				
United States	110 521	6,852,000	123 807	8,920,000
Japan	-	-	284	37,000
Italy	108	10,000	17	2,000
United Kingdom	12	2,000	-	-
Total	110 641	6,864,000	124 108	8,959,000
White cement				
United States	15 345	1,921,000	4 938	480,000
Japan	625	71,000	890	122,000
France	-	-	19	1,000
Belgium and Luxembourg	432	43,000	-	-
Total	16 402	2,035,000	5 847	603,000
Aluminous cement				
United States	9 980	2,224,000	10 489	2,732,000
United Kingdom	2	...	184	63,000
Yugoslavia	123	17,000	-	-
Total	10 105	2,241,000	10 673	2,795,000

TABLE 1. (cont'd)

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Cement, nes				
United States	56 688	4,041,000	72 513	6,123,000
Italy	405	37,000	888	101,000
United Kingdom	154	32,000	182	47,000
France	-	-	31	11,000
West Germany	38	3,000	32	4,000
Switzerland	-	-	14	3,000
Total	57 285	4,113,000	73 660	6,289,000
Total cement imports	194 433	15,253,000	214 288	18,646,000
Refractory cement and mortars				
United States		9,276,000		10,858,000
United Kingdom		1,065,000		1,169,000
Ireland		537,000		329,000
West Germany		71,000		198,000
Austria		7,000		34,000
Other countries		40,000		17,000
Total	..	10,996,000	..	12,605,000
Cement and concrete basic products, nes				
United States		2,194,000		2,616,000
United Kingdom		13,000		55,000
France		19,000		21,000
West Germany		36,000		9,000
Other countries		22,000		-
Total	..	2,284,000	..	2,701,000
Cement clinker				
United States	19 119	587,000	446	28,000
Italy	-	-	50	2,000
Japan	34 690	1,240,000	-	-
United Kingdom	180	45,000	-	-
Total	53 989	1,872,000	496	30,000

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Producers' shipments plus quantities used by producers. [2] Includes small amounts of other cement.
P Preliminary; .. Not available; - Nil; nes Not elsewhere specified; ... Amount too small to be expressed.

Cement Inc. closed its Kingston, New York, plant and had its shipments of cement and clinker into New York state drastically curtailed. Lake Ontario Cement Limited and St. Marys Cement Limited, both shipping into the Michigan area, have felt the effect of unemployment in that state's automobile industry being translated into a much lower demand for housing.

In the western region low demand for cement in the United States caused Inland Cement Industries Limited to close its new Tilbury Island, British Columbia, plant for two months in late summer. Its Bamberton, British Columbia plant, scheduled for permanent closure when market demand could be supplied by Tilbury, was also shut down and its renewed operation is doubtful, especially in face of strike action taken against both plants in mid-November.

Inland's Edmonton plant began operation of its new dry kiln in mid-November. This

TABLE 2. CANADA, CEMENT PRODUCTION, SHIPMENTS, TRADE AND CONSUMPTION, 1970, 1975-80

	Production	Shipments[1]	Exports[2]	Imports[2]	Apparent Consumption[3]
			(tonnes)		
1970	7 304 813	7 208 411	513 941	88 172	6 782 644
1975	9 740 502	10 193 984[r]	934 981	420 430	9 679 433[r]
1976	9 898 024	9 515 452[r]	921 031	314 680	8 909 101[r]
1977	9 933 135	9 639 679	1 274 652	257 812	8 622 839
1978	10 472 724	10 558 279	1 634 583	217 925	9 141 621
1979	11 459 509	11 765 248	2 288 822	194 433	9 670 859
1980[p]	10 340 302	10 497 000	1 527 508	214 288	9 183 780

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Producers' shipments plus quantities used by producers. [2] Does not include cement clinker, but does include exports from other than producer plants. [3] Producers' shipments plus imports, less exports.
[p] Preliminary; [r] Revised.

phase of the company's multi-million dollar expansion project put into operation the first preheater-precalciner cement production unit in Canada.

CANADIAN PRODUCTION DISTRIBUTION

The Canadian cement industry is strongly regionalised on the basis of market availability. Capacity concentration is closely aligned to population density, reflecting the importance of transportation costs to the consumer. The availability and cost of energy could weigh just as heavily as product transportation costs on decisions regarding new plant locations in future, and perhaps even on the viability of existing plants.

Table 3 has been altered in this review to illustrate clinker production capacity as of the end of 1980 from published information released by The Canadian Portland Cement Association. A plant generally has a slightly greater capacity to grind clinker than it has to produce clinker. Although Inland's Edmonton plant began to operate a new kiln in November, the increased capability is not indicated in Table 3 because of the misleading impression this would impart to a capacity utilization calculation. Inland does not include the Bamberton plant as a producer. CCL has ceased to show the Montreal East and Hull plants as having grinding facilities, in fact, the Hull plant has been closed completely and is not even functioning as a terminal.

The three plants in the **Atlantic region** constitute about 6 per cent of total clinker producing capacity. All three obtain raw materials at or near the plant site. North Star Cement Limited purchases gypsum from Flintkote Holdings Limited, which quarries at Flat Bay about 65 km south of Corner Brook while National Gypsum (Canada) Ltd. supplies the Brookfield plant of Canada Cement Lafarge Ltd. from its Milford, N.S. quarry. CCL's New Brunswick plant quarries its own gypsum at Havelock. The region used over 440 000 tonnes (t) of cement in 1980, down some 17 per cent from 1979 and representing 5.5 per cent of total Canadian consumption.

In the **Quebec region** the five clinker-producing plants have 25.6 per cent of the Canadian total in an area that has 26.6 per cent of Canadian population and which, in 1980, consumed about 1.6 million t of portland cement or 20 per cent of total consumption, down by 12 per cent from 1979. The depressed construction markets have led CCL to close its Hull, Quebec terminal and to forego the rehabilitation of its Montreal East plant. Miron Cement Ltd. is supplying a major share of the portland cement requirements to the James Bay Development Corporation hydroelectric

TABLE 3: CEMENT PLANTS, APPROXIMATE ANNUAL GRINDING CAPACITY, END OF 1980

Company	Plant	Wet, Dry, Pre-heater	Fuel (Coal Oil Gas)	No. of Kilns	Grinding Capacity Tonnes a Year (000)	Clinker Capacity Tonnes a Year (000)
Atlantic						
Canada Cement Lafarge Ltd.	Brookfield, N.S.	D	C,O	2	580	469
	Havelock, N.B.	D	C	2	330	268
North Star Cement Limited	Corner Brook, Nfld.	Dx	O	1	250	130
Atlantic Region Total				5	1 160	867
Quebec						
Canada Cement Lafarge Ltd.	St. Constant	D	O,G	2	950	910
Ciment Quebec Inc.	St. Basile	W	O	2	480	308
Miron Company Ltd.	Montreal	D	O	2	675	838
St. Lawrence Cement Inc.	Beauport	W	C,O	2	625	644
(Independent Cement Inc.)	Joliette	D	O	4	1 000	976
Quebec Region Total				12	3 730	3 676
Ontario						
Canada Cement Lafarge Ltd.	Woodstock	W	C,O,G	2	1 162	476
	Bath	Dx	O,G	1	770	866
Federal White Cement	Woodstock	D	O	1	100	96
Lake Ontario Cement Limited	Picton	D,Dx	C,O,G	4	680	1 442
Medusa Products Company of Canada, Limited	Paris[1]					
St. Lawrence Cement Inc.	Clarkson	W,Dx	C,O	3	2 300	1 541
St. Marys Cement Limited	Bowmanville	W	C	2	790	602
	St. Marys	W,Dx	O,G	3	800	991
Ontario Region Total				16	6 602	6 014
Prairies						
Canada Cement Lafarge Ltd.	Fort Whyte, Man.	W	O,G	2	498	465
	Floral, Sask.[1]				220	
	Exshaw, Alta.[3]	D	G	3	596	660
	Edmonton, Alta.[1]				215	
Inland Cement Industries Ltd.[2]	Winnipeg, Man.	W	O,G	1	450	335
	Regina, Sask.	D	O,C	1	250	236
	Edmonton, Alta.[4]	W	O,G	3	1 000	506
Prairies Region Total				10	3 229	2 202
British Columbia						
Canada Cement Lafarge Ltd.	Kamloops	D	O,G	1	196	190
	Richmond	W	O,G	2	404	445
Inland Cement Industries Ltd.[2]	Tilbury Island	Dx	O,G	1	1 042	950
B.C. Region Total				4	1 642	1 585
CANADA TOTAL (9 companies)				47	16 363	14 344

Source: Market and Economic Research Department, Portland Cement Association.

[1] Grinding plants only. [2] Controlled by Genstar. [3] Expansion program continuing.
[4] Expansion program completed late 1980, increased capacity not shown.

TABLE 4. CANADA, CEMENT PLANTS, KILNS AND CAPACITY UTILIZATION, 1975-80

	Clinker Producing Plants	Kilns	Approximate Cement Grinding Capacity[1]	Portland Cement Production[2]	Clinker Exports[3]	Approximate Total Production[4]	Capacity Utilization
			(tpy)	(t)	(t)	(t)	(%)
1975	24	57	15 064 000	9 740 502	658 954	10 399 456	69
1976	22	51	14 987 000	9 898 024	645 377	10 543 401	70
1977	22	49	14 885 000	9 933 135	775 145	10 708 280	72
1978	24	51	15 985 000	10 472 724	1 077 274	11 549 998	72
1979	24	51	15 985 000	11 765 248	1 530 537	13 295 785	83
1980	23	47	16 363 000[5]	10 497 000[6]	800 374	11 297 374	69

Sources: Statistics Canada, U.S. Bureau of Mines, Portland Cement Association (PCA)

[1] Includes two plants that grind only. [2] Producers' shipments together with amounts used by producers. [3] Imports to United States from Canada. [4] Cement shipments plus clinker exports. [5] Adjusted to agree with PCA information; does not include changes at Exshaw in effect late November 1980. [6] Preliminary figure.

project. The company has undertaken a $13 million anti-pollution program ranging from site protection to the utilization of methane gas from a garbage disposal project on the company's property. St. Lawrence Cement Inc. expects significant cost savings as a result of conversion to coal in their kilns at Joliette and at Beauport. The company closed its Kingston, New York plant and further integrated into the concrete products field with the purchase of two Ontario based ready-mix operations.

Ciment Québec Inc. continued through 1980 with the installation of a Fuller suspension preheater with a precalciner flash furnace system of 2 000 tpd capacity to replace the existing wet plants.

Portland cement consumption was down some 7 per cent in the **Ontario region** to only 32 per cent of total Canadian consumption. The region has nearly 50 per cent of the nation's clinker producing capacity. Exports of cement from Ontario to the United States were reduced by nearly 50 per cent in 1980 compared to a 33 per cent reduction from all of Canada. The highly integrated Canada Cement Lafarge Ltd. experienced prolonged strikes at many of its plants during the latter third of 1980 and extending into the first quarter of 1981. The company has brought into production about 3 million t of new cement capacity over the past seven years and currently over half of its operating kilns are less than 10 years old. The limestone for CCL's Bath, Ontario plant is quarried on site while silica is supplied from a Potsdam sandstone at Pittsburgh about 65 km east of Bath and iron oxide is purchased from Hamilton. Gypsum is from Nova Scotia. The Woodstock plant has experimented with the use of selected, processed garbage as fuel. The plant obtains limestone on site, silica from Indusmin Limited, iron oxide from Stelco Inc. and gypsum from southern Ontario mines.

Lake Ontario Cement Limited continued to integrate into the concrete products and construction field in Canada during 1980. The company exported significantly less cement and clinker into western New York state and Michigan than in 1979 and was forced to shut down all its kilns at the Picton plant for six weeks at mid-year to adjust plant inventory. Improved performance of the five year old preheater system resulted in energy savings and a greater use of coal.

At its Mississauga plant, St. Lawrence Cement Inc. has continued to research energy saving techniques. The company obtains limestone from Ogden Point, 160 km east of Toronto on the shore of Lake Ontario and gypsum is purchased from Nova Scotia or from southern Ontario mines.

TABLE 5. CANADA, DISTRIBUTION OF DOMESTIC CEMENT SALES[1] FROM PRODUCERS' PLANTS, 1976-1980

	1976	1977	1978	1979	1980
			(tonnes)		
Quebec					
Portland	2 006 578	1 991 607	1 818 456	1 817 792	1 609 900
Masonry	87 379	89 899	80 672	78 617	68 564
Total	2 093 957	2 081 506	1 899 128	1 896 409	1 678 464
Ontario					
Portland	3 051 287	2 920 972	2 819 248	2 734 519	2 537 150
Masonry	194 355	182 809	171 622	173 507	144 394
Total	3 245 642	3 103 781	2 990 870	2 908 026	2 681 544
Other Provinces					
Portland	3 383 503	3 369 219	3 720 725	3 875 740	3 815 150
Masonry	65 495	70 709	63 273	66 698	59 470
Total	3 448 998	3 439 928	3 783 998	3 942 438	3 874 620
Canada					
Portland	8 441 368	8 281 798	8 358 429	8 428 051	7 962 200
Masonry	347 229	343 417	315 567	318 822	272 428
Total	8 788 597	8 625 215	8 673 996	8 746 873	8 234 628
Exports					
Portland	734 421	1 071 889	1 390 243	1 817 243	1 626 502
Masonry	24 053	24 887	38 595	43 158	25 349
Total	758 474	1 096 776	1 428 838	1 860 401	1 651 851
Clinker[2]	645 377	775 195	1 077 274	1 530 537	W
Total Sales					
Portland	9 175 789	9 353 687	9 748 672	10 245 294	9 588 702
Masonry	371 282	368 304	354 162	361 980	297 777
Total cement	9 547 071	9 721 991	10 102 834	10 607 274	9 886 479
Total clinker[3]	645 377	775 195	1 077 274	W	496 214

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Does not include amounts used at producers' plants sites. [2] United States Bureau of Mines, Division of Non-Metallic Minerals for years 1976 and 1977. Statistics Canada for 1978 to 1980. [3] Interplant shipments are not reported for 1978 to 1980.
W Withheld to avoid disclosing confidential company data.

The Bowmanville plant of St. Marys Cement Limited was expanded in 1973 with the addition of a second kiln. With the acquisition of Wyandotte Cement Inc., the company began shipments of clinker through a newly constructed lakefront loading facility at Bowmanville. The original plant at St. Marys, constructed in 1912 to serve the Toronto area, has been expanded and modernized over the years, most recently with the installation of a 680 000 tpy kiln and four-stage suspension preheater.

Medusa Products Company of Canada, Limited, Paris, Ontario grinds a white clinker imported from the Medusa plant at York, Pennsylvania. The white cement is sold mainly in Ontario.

Federal White Cement's new plant at Woodstock, can produce up to 100 000 tpy of white cement. Limestone is purchased from Canada Cement Lafarge's Woodstock quarry.

Two companies, Canada Cement Lafarge Ltd. and Inland Cement Industries Limited operate a total of five clinker producing plants in the **Prairie region** and three in the **Pacific region** along with two clinker grinding plants. This **Western region** has 27.6 per cent of clinker producing capacity, excluding the recently completed expansion at Inland's Edmonton, Alberta plant and removing the capacity of that company's Bamberton, British Columbia plant. Consumption of portland cement in the western provinces accounted for 42.8 per cent of Canadian total, up 2.4 per cent while Canadian consumption as a whole was down 5.0 per cent. Cement and clinker were again imported from the eastern producers to meet the high demand. Expansions at Edmonton and at Canada Cement Lafarge's Exshaw plant will increase capacity by about 1.3 million tpy through 1981.

CCL's Winnipeg plant obtains limestone from the company's quarry at Steep Rock on Lake Manitoba, gypsum from Westroc Industries Limited at Amaranth, silica from Beausejour and clay adjacent to the plant site at Fort Whyte. Raw material for the Exshaw plant is mainly from the plant site but for gypsum from Westroc and iron oxide from Cominco Ltd. Limestone from Texada Island supplies the company's Vancouver plant at Richmond.

A limestone quarry at Mafeking, Manitoba, near the Manitoba-Saskatchewan border, supplies limestone to Inland's Regina plant, while the Winnipeg plant is supplied from Steep Rock, Manitoba. The Edmonton plant is supplied from Cadomin, Alberta using a 4 500 t unit train and an automated materials-handling system. A $6 million expansion program is planned for the Cadomin quarry, and a further $27 million is to be spent for new grinding and storage facilities at Edmonton. Inland's Vancouver plant on Tilbury Island, after experiencing start-up difficulties, produced satisfactorily during 1980 until closed by strike action in November. Negotiations carried well into 1981 and the closure contributed to cement shortages despite the reduced export market. Limestone for Tilbury is barged from Texada Island.

TECHNOLOGY

Portland cement is produced by burning, usually in a rotary kiln, an accurately proportioned, finely ground mixture of limestone, silica, alumina and iron oxide. Kiln discharge, in the shape of rough spheres, is a fused, chemically complex mixture of calcium silicates and aluminates termed clinker, which is mixed with gypsum (4 to 5 per cent by weight) and ground to a fine powder to form portland cement. By close control of the raw mix, the burning conditions and of the use of additives in the clinker-grinding procedure, finished cements displaying various desirable properties can be produced.

The three basic types of portland cement, Normal Portland, High-Early-Strength Portland, and Sulphate-Resisting Portland, are produced by most Canadian cement manufacturers. Moderate Portland Cement and Low-Heat-of-Hydration Portland Cement, designed for use in concrete to be poured in large masses, such as in dam construction, are manufactured by several companies in Canada. Masonry cement (generic name) includes such proprietary names as Mortar Cement, Mortar Mix (unsanded), Mason's Cement, Brick Cement and Masonry Cement. The latter product produced by portland cement manufacturers, is a mixture of portland cement, finely ground high-calcium limestone (35 to 65 per cent by weight) and a plasticizer. The other products do not necessarily consist of portland cement and limestone, and may include a mixture of portland cement and hydrated lime and/or other plasticizers.

TABLE 6. CANADA, MINERAL RAW MATERIALS[1] USED BY THE CEMENT INDUSTRY, 1978 AND 1979

Commodity	1978	1979P
	(tonnes)	
Limestone	12 284 058	17 803 408
Shale	700 458	X
Clay	655 977	X
Gypsum	481 772	616 599
Sand	349 255	608 836
Iron oxide	116 404	150 342
Sandstone	66 336	57 018

Source: Statistics Canada.

[1] Includes purchased materials and material produced from own operations.
P Preliminary; X Withheld to avoid disclosing confidential company data.

TABLE 7. PLANNED CAPACITY CHANGES AS OF END OF 1980

Company	Plant Location	Net Capacity Change Compared With Table 3 (tpy)	Expected Date of Completion	Remarks
Quebec				
Ciment Quebec Inc.	St. Basile	427 000	1982	Replacing existing 2-kiln, wet process plant with 735 000 tpy suspension preheater, flash calciner system.
Ontario				
St. Lawrence Cement Inc.	Clarkson	140 000	1981	Removing one wet kiln, converting one preheater kiln to a precalciner.
Prairie Region				
Canada Cement Lafarge Ltd.	Exshaw, Alta.	533 000	1981	Removing one dry kiln, adding a 624 000 tpy dry kiln. (Actually became operative in late November 1980).
Inland Cement Industries Limited	Edmonton, Alta.	726 000	1981	Total expenditures on plant expansion will be $144 million for a new dry kiln, grinding and storage facilities.

TABLE 8. CANADA, HOUSE CONSTRUCTION, BY PROVINCE, 1979 AND 1980

	Starts			Completions			Under Construction		
	1979	1980	% Diff.	1979	1980	% Diff.	1980	1978	% Diff.
Newfoundland	2,999	3,848	+28	2,611	2,986	+14	2,850	3,736	+31
Prince Edward Island	1,068	475	-55	1,173	692	-41	403	179	-56
Nova Scotia	4,538	3,895	-14	6,132	4,512	-26	3,634	2,762	-24
New Brunswick	5,021	2,646	-47	5,090	3,258	-36	1,951	1,318	-32
Total (Atlantic Provinces)	13,626	10,864	-20	15,006	11,448	-24	8,838	7,995	-10
Quebec	41,730	29,186	-30	44,288	33,560	-24	20,413	14,639	-28
Ontario	56,887	40,127	-29	76,570	54,021	-29	44,851	31,187	-30
Manitoba	5,772	2,597	-55	8,410	4,503	-46	4,992	2,694	-46
Saskatchewan	11,742	6,250	-47	10,865	7,763	-29	8,640	6,022	-30
Alberta	39,947	32,031	-20	44,492	34,717	-22	25,454	20,378	-20
Total (Prairie Provinces)	57,461	40,878	-29	63,767	46,983	-26	39,086	29,094	-26
British Columbia	27,345	37,546	+37	26,858	30,156	+12	15,413	22,865	+48
Total Canada	197,049	158,601	-20	226,489	176,168	-22	128,601	105,780	-18

Source: Statistics Canada.

TABLE 9. WORLD PRODUCTION OF CEMENT, 1969, 1979 and 1980

	1969	1979^P	1980^e
		(000 tonnes)	
U.S.S.R.	89 777	123 018	127 000
Japan	50 784	87 131	81 600
United States (including Puerto Rico)	68 152	71 805	70 800
People's Republic of China	22 500	47 000^e	63 500
Italy	31 357	39 484	36 300
West Germany	34 422	34 708	31 800
France	27 896	31 233	27 200
Spain	16 015	29 315	27 200
Brazil	7 823	24 874	..
Poland	11 830	19 180	..
India	13 624	18 249	..
Republic of Korea	4 865	16 614	..
United Kingdom	17 573	16 240	13 600
Romania	7 512	15 600	..
Mexico	6 674	15 150	..
Turkey	5 795	13 906	..
East Germany	7 404	13 000^e	..
Greece	4 939	12 098	..
Canada	7 484	11 765	10 497
Other countries	114 074	205 096	327 000
Total	550 500	845 466	816 500

Sources: Energy, Mines and Resources, Canada; Cembureau, World Statistical Review; U.S. Bureau of Mines, Mineral Commodity Summaries, 1981.

^{P} Preliminary; ^{e} Estimated; .. Not available.

Cement has little use alone but, when combined with water, sand, gravel, crushed stone or other aggregates in proper proper proportions acts as a binder, cementing the materials together as concrete. Concrete has become a widely used and readily adaptable building material which can be poured on site in large engineering projects, or used in the form of delicate precast panels or heavy, prestressed columns and beams in building construction.

Concrete research has generally been confined to strength determination, durability, placement and curing. Currently, great emphasis is being placed on researching the use of superplasticizers in concrete. Super-plasticizers, a group of admixtures described chemically as naphthalene or melanine sulphonate polymers, have been found to provide greatly increased workability over short time spans or to provide high strength by permitting lower water-cement ratios.

SPECIFICATIONS

Portland cement used in Canada should conform to the specifications of CAN 3-A5-M77, published by the Canadian Standards Association. This standard covers the five main types of portland cement. Masonry cement produced in Canada should conform to the CAN 3-A8-M77.

The cement types manufactured in Canada, but not covered by the CSA standards, generally meet the appropriate specifications of the American Society for Testing and Materials (ASTM).

Cembureau, The European Cement Association, has published **Cement Standards of the World - Portland Cement and its Derivatives**, in which standards are compared. Cembureau's **World Cement Directory** lists production capacities by country and by company.

TABLE 10. APPARENT CONSUMPTION OF CEMENT BY THE LEADING PRODUCERS, 1979

	Production^p	Apparent Consumption	Apparent Consumption
	(000 tonnes)		(kg/capita)
U.S.S.R.	123 018	119 618^e	453^e
Japan	87 131	81 842	705
United States (including Puerto Rico)	71 805	75 671	338
People's Republic of China	47 000^e	46 460^e	49^e
Italy	39 484	37 906	666
West Germany	34 708	33 874	552
France	31 233	27 693	518
Spain	29 315	20 791	559
Brazil	24 874	24 847	209
Poland	19 180	17 480^e	496^e
India	18 249	19 649^e	30^e
Republic of Korea	16 614	15 825	424
United Kingdom	16 240	15 221	273
Romania	15 600	12 600^e	571^e
Mexico	15 150	14 700^e	212^e
Turkey	13 906	12 727	287
East Germany	13 000^e	12 030^e	719^e
Greece	12 098	7 170	760
Canada	11 765	9 671	408
Other countries	205 096		
Total	8 454 600		

Source: Energy, Mines and Resources Canada; Cembureau, World Statistical Review.

^{p} Preliminary; ^{e} Estimated.

Regulations governing the design and application of these and other associated materials of construction are generally covered by CSA Standards or by those of the American Concrete Institute.

Although individual companies continued to conduct research in relation to cement production, much experimentation concerning the use of cement and concrete is done through the Portland Cement Association (PCA), an industry-supported, nonprofit organization whose purpose is to improve and extend the uses of cement and concrete through scientific research and engineering fieldwork. The Association is active in all parts of Canada, and can offer detailed information on concrete use, design and construction from regional offices of the Canadian Portland Cement Association.

MARKETS AND TRADE

Cement markets are regional and centred in developing urban areas where construction activity is concentrated, or in areas where mining or heavy engineering construction projects are being carried out. The normal market area of a given cement-producing plant depends on the amount of transportation cost that the selling price can absorb. A potential large volume of sales could warrant a secondary distribution terminal; water transportation to a distribution system could extend a plant's market area even farther. Because raw materials for cement manufacture are generally widespread, most countries can supply their own cement requirements if the market volume warrants a plant. Few countries rely entirely on imports for their cement needs. However, some countries rely heavily on export markets for their surplus cement production in order to operate facilities economically.

Specialty cements such as white cement can be transported greater distances than ordinary grey portland cement because the transportation costs do not represent as

TABLE 11. CANADA, VALUE OF CONSTRUCTION[1] BY PROVINCE, 1979-81

	1979			1980			1981		
	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total
					($ 000)				
Newfoundland	416 092	446 765	862 857	447 694	386 786	834 480	556 139	534 904	1 091 043
Nova Scotia	627 216	452 579	1 079 795	622 763	579 219	1 201 982	761 059	821 399	1 582 458
New Brunswick	594 170	476 357	1 070 527	531 303	433 661	964 964	575 808	469 438	1 045 246
Prince Edward Island	123 280	59 977	183 257	99 614	64 226	163 840	98 496	63 289	161 785
Quebec	4 924 241	4 200 352	9 124 593	5 014 341	4 278 886	9 293 227	5 464 094	4 911 412	10 375 506
Ontario	7 794 586	3 775 774	11 570 360	7 965 310	4 042 331	12 007 641	8 621 518	4 768 029	13 389 547
Manitoba	959 281	510 719	1 470 000	865 835	496 251	1 362 086	832 839	611 990	1 444 829
Saskatchewan	1 217 977	885 247	2 103 224	1 169 326	1 044 053	2 213 379	1 284 539	1 569 280	2 853 819
Alberta	4 717 389	4 655 649	9 373 038	5 073 851	6 144 574	11 218 425	6 080 995	7 523 132	13 604 127
British Columbia, Yukon and Northwest Territories	3 331 675	2 853 540	6 185 215	4 333 442	3 475 690	7 809 132	4 913 854	3 956 488	8 870 342
Canada	24 705 907	18 316 959	43 022 866	26 123 479	20 945 677	47 069 156	29 189 341	25 229 361	54 418 702

Source: Statistics Canada.

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[1] Actual expenditures 1979, preliminary actual 1980, intentions 1981.

high a proportion of the landed price, and because quantities required are generally much smaller than for portland cement.

Cement shortages in countries experiencing a buoyant surge in construction have led to exceptions to the norm and resulted in cement being shipped unusual distances. The state of the portland cement industry in the United States, and a surprisingly large demand for cement in construction particularly in the west and midwest, created improved export opportunities for Canadian portland cement during the late 1970s.

The opportunity for the United States to import energy in the form of cement clinker, while also avoiding the environmental problems associated with kiln operations, could become attractive.

A typical feature of the cement-manufacturing industry is its diversification and vertical integration into related construction material industries. Many cement companies also supply ready-mix concrete, stone, aggregates and pre-formed concrete products such as slabs, bricks and prestressed concrete units.

In Canada, construction is categorized broadly as building construction and engineering construction, and the values of each type, discounted by inflationary factors, provide a basis for comparison of annual construction in place. In current dollars, construction is credited with about 17 per cent of gross national expenditure. In 1980 capital and repair expenditure on construction was about 47.5 billion, up 12 per cent over expenditures in 1979. Housing starts in 1980 were 158,601, down from 197,049 starts in 1979. Expectations are that demand for single detached units will increase despite high interest rates in 1981 and that total starts of all types will be about 181,000 units.

ENERGY UTILIZATION

Cement manufacture is energy-intensive. It is obvious that research should be concentrated in this area, and specifically within the pyroprocessing sector where over 80 per cent of the energy is consumed. Raw material grinding and finish grinding are being studied to determine optimum particle size for energy consumed.

In terms of the energy required to make concrete components and to build concrete structures, along with energy requirements to service and maintain them, they are not so energy-intensive as the nearly 6 giga joules required per t of cement would at first indicate.

Energy conservation programs adopted by the Canadian cement industry resulted in reaching the goal of a 9 to 12 per cent reduction in energy consumption per unit of production, based on 1974 calculations. In 1980 the average plant consumption of energy of all types was 5,326 mega joules a tonne, a 14.4 per cent fuel saving over 1974.

A change in the fuel mix from 1974 to 1980 is noted. In 1974 natural gas accounted for 49.5 per cent, petroleum products 39.7 per cent and coal and coke 10.8 per cent. For 1980 natural gas usage was 37.3 per cent of the total energy requirements while petroleum products were 27.1 per cent and coal and coke rose to 25.6 per cent.

In Canada in 1980 eight plants used coal as primary fuel, seven used oil and eight used natural gas. Seven plants had a capability to used oil as an alternate fuel while six could convert to natural gas usage and one plant could use either oil or gas as alternatives - nine plants had no alternate fuel capability.

The dry process now accounts for 67 per cent of Canadian portland cement capacity.

OUTLOOK

Growth in construction spending will undoubtedly be greatest in Alberta and British Columbia during 1981. The major cement producers expect continued growth in construction with modest gains in the short-term and, as in the past two or three years, also expect activity to range from promising through cautious. There is a good possibility that construction expenditures could increase in Atlantic regions as a result of offshore drilling activity.

The cement industry in Canada is capable of meeting immediate demands and is also capable of expansion to meet even greater demand from domestic and foreign markets should opportunities be presented.

TABLE 12. CANADA, VALUE OF CONSTRUCTION[1] BY TYPE, 1979-81

	1979	1980	1981
		($ million)	
Building Construction			
Residential	14,267	13,776	15,417
Industrial	2,068	2,565	2,845
Commercial	5,074	6,011	6,870
Institutional	1,831	2,108	2,314
Other building	1,466	1,663	1,743
Total	24,706	26,123	29,189
Engineering Construction			
Marine	235	256	331
Highways, airport runways	3,380	3,510	3,730
Waterworks, sewage systems	1,863	2,000	2,251
Dams, irrigation	174	202	247
Electric power	4,279	4,110	4,802
Railway, telephones	1,621	1,891	2,073
Gas and oil facilities	4,643	6,326	8,320
Other engineering	2,122	2,651	3,475
Total	18,317	20,946	25,229
Total construction	43,023	47,069	54,418

Source: Statistics Canada.

[1] Actual expenditures 1979, preliminary actual 1980, intentions 1981.

The already-established trend to dry processing and the use of preheaters will continue for new plants, and the rehabilitation of older plants will continue to benefit from new technology. Rebuilding programs are costly, especially when they must be accomplished with no loss of production. The obvious incentives of cost savings and greater profits must be attractive enough to warrant the additional expense and effort. The expense of adapting older facilities to meet newly imposed environmental-control regulations can contribute to a decision in favour of a new plant - such decisions have forced a number of plant closures in the United States. Continued diversification and vertical integration by cement producers will eventually result in the writeoff of some comparatively inefficient production capacity as the emphasis is placed on cement and concrete together.

Although labour relations have shown some improvement in the construction industry, work stoppages have continued to seriously delay some major projects. Such situations do great harm to an industry trying to improve its visability and public image and to reduce its cyclical nature. The shortage of skilled labour could reach problem proportions for the construction industry; if not generally, then certainly in some regions, as more and larger projects are undertaken.

WORLD REVIEW

Because of the direct relationship between cement, concrete, and construction, the consumption of cement can be monitored as an indication of a country's rate of development.

World production of cement in 1980 is estimated at 900 million t, down from about 940 million t in 1979 and below estimates made a few years ago. Developing countries, particularly oil-producing countries, continue to show increasing demand for cement and cement-manufacturing facilities. Involvement of corporations with highly specialized expertise in the building of cement production facilities in developing countries has become quite common.

Conservation of energy and raw materials within the cement industry is of worldwide concern and provides a theme around which major developments in the industry have taken place. Of particular note is the emphasis on blended cements and the utilization of slag, ash and other byproducts. Even greater additions to production capacities than those witnessed during the past few years will be needed to meet demand in many developing countries.

A review of the international cement scene is provided in the April 1981 issue of **Rock Products,** a publication of MacLean-Hunter Publishing Corp., Chicago, Illinois.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(cents per hundred pounds)			
29000-1	Portland and other hydraulic cement, nop; cement clinker	free	free	6	free
29005-1	White, nonstaining Portland cement	4	4	8	2 2/3

MFN Reductions under GATT (effective January 1 of year given)

	1980	1981	1982	1983	1984	1985	1986	1987
	(cents per hundred pounds)							
29005-1	4.0	3.9	3.9	3.9	3.8	3.8	3.7	3.7

UNITED STATES

Item No.		
511.11	White, nonstaining Portland cement per 100 pounds including weight of container	1¢
511.14	Other cement and cement clinker	free
511.21	Hydraulic cement concrete	free

		1980	1981	1982	1983	1984	1985	1986	1987
		(% ad valorem)							
511.25	Other concrete mixed, per cubic yard	7.2	6.9	6.5	6.2	5.9	5.6	5.2	4.9

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated 1980, USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241.

Chromium

D.G. LAW-WEST

Canada imports all of its chromium requirements, largely in the form of ore and ferrochromium. In 1980 imports of chromite ore increased about 4 per cent over 1979 to 28 373 tonnes (t). At the same time imports of ferrochromium rose nearly 20 per cent to 41 364 t, reflecting increased consumption by the Canadian stainless and specialty steel industries. Virtually all imported chromite ores are consumed by the refractory brick industry. The stainless and specialty steel producers, the major users of ferrochromium, have imported their requirements since 1975 when the last domestically produced stocks of ferrochromium were sold.

Notwithstanding large resources of chromite in the Bird River area of Manitoba and the Eastern Townships of Quebec, Canada does not mine chromite ores.

The Bird River deposits are a continuous band of chromite mineralization, similar in type to the important chromite deposits in Zimbabwe and the Republic of South Africa. However, the Bird River deposits have been considered uneconomic because most of the mineralization is low-grade, containing 10 to 20 per cent chromic oxide (Cr_2O_3), and has a low chromium-to-iron ratio.

Chromite mineralization in the Eastern Townships, which was exploited early in the century and during the Second World War, occurs as discontinuous and podiform deposits. Although these small deposits are generally satisfactory in grade and composition, they are not well defined and require further exploration to delineate and quantify the resource potential. The region has not been systematically explored, largely because the mineral rights are held by many independent land owners.

WORLD DEVELOPMENTS

Zimbabwe chromium became available on world markets following the lifting of trade sanctions in December, 1979. By late February, 1980 the first post-sanction shipments of ferrochromium from Zimbabwe had arrived in the United States. The full impact of chromite and chromium alloys from Zimbabwe on the world market is not expected to be felt in the short-term because it will take time to bring idled capacity back into production. In this regard Union Carbide Corporation, is planning to restart two idled furnaces at its Rhomet ferrochromium plant by the end of 1981. Production from the plant is expected to reach 200 000 tonnes per year (tpy) of high-carbon ferrochromium.

The Malvernia railroad, a direct link between Zimbabwe and the port of Maputo in Mozambique, resumed operation at the end of 1980 after being damaged during the conflict between the two countries. While

TABLE 1. CANADA, CHROMIUM IMPORTS, 1979 AND 1980

	1979		1980P	
	(tonnes)	($000)	(tonnes)	($000)
Imports				
Chromium in ores and concentrates				
United States	11 122	2,326	7 769	2,839
The Philippines	3 865	1,296	5 970	2,087
Mozambique	9 166	1,404	9 288	1,685
Albania	-	-	4 720	747
Other countries[1]	3 220	886	626	234
Total	27 373	5,912	28 373	7,592
Ferrochromium				
United States	12 707	9,663	10 514	9,752
South Africa	15 923	7,121	19 836	9,713
Brazil	4 350	1,786	7 600	4,165
Other countries[2]	1 740	1,941	3 414	3,586
Total	34 720	20,511	41 364	27,216
Chromium sulphates, including basic				
United States	1 379	932	1 477	1,222
United Kingdom	186	149	231	257
West Germany	39	33	61	68
Poland	36	24	-	-
Total	1 640	1,138	1 769	1,547
Chromium oxides and hydroxides				
United States	1 780	3,916	1 624	4,038
United Kingdom	75	181	57	219
Italy	-	-	33	79
West Germany	53	160	2	10
Total	1 908	4,257	1 716	4,346
Chromium dyestuffs				
West Germany	7	162	8	103
United States	9	76	9	84
The Netherlands	9	45	3	38
Other countries[3]	15	60	16	95
Total	40	343	36	320

Source: Statistics Canada.

[1] Includes West Germany, The Netherlands, Greece, Sweden, Finland, Turkey. [2] Includes Norway, Sweden, Yugoslavia. [3] Includes Italy, People's Republic of China, Poland, Switzerland, United Kingdom and Japan.
P Preliminary; - Nil.

the rail line will be used to carry chromite and ferrochromium, it is expected that South African ports will remain important loading points for shipments from Zimbabwe. In addition to its metallurgical grade chromite and high quality ferrochromium, Zimbabwe has excellent grades of chromite for refractory applications and could become an important supplier of this product.

The South African chromite industry experienced a year of oversupply and low prices, and 1980 production was reported to have fallen to between 50 and 60 per cent of 1979 levels. Japan, one of South Africa's chief ore customers, drastically cut back its orders so as to reduce excessive inventories of chromite that had been purchased at low prices during 1979. In addition, higher ocean freight costs made the closer Indian and Philippine chromite more attractive to the Japanese. Ferrochromium producers in South Africa fared little better than the chromite ore producers and operated at about 70 per cent of capacity.

The Philippines was the centre of activity for chromite mine developments during 1980. Trident Mining & Industrial Corp. improved its concentrate grade from 48 per cent Cr_2O_3 to about 54 per cent Cr_2O_3. This super-high-grade concentrate is intended to compete with premium material from India, which can be added directly to electric furnaces without being processed to ferrochromium. Bayer AG., through its wholly owned subsidiary Alamag Corporation, has announced plans to build a chromite ore treatment plant on the central Philippine island of Samar. The Samar plant will be operational by 1983 and could attain capacity throughput of 30 000 tpy of ore by 1985. Alamag has indicated that the plant will ultimately be expanded to process 100 000 tpy of ore into chemical-grade concentrates. Island Mining and Industrial Corp. (IMIC) plans to build an ore processing plant and have it in production by 1983. The plant will be located at Isabela, 320 kilometres northeast of Manila where nearly 2 million t of chromium ore has been discovered.

India expects to have an additional 50 000 tpy plant capacity for carbon ferrochromium by the end of 1982. Two Japanese companies won the contract to construct the plant, which will be located at Baudpur, Orissa State.

Hellenic Ferroalloys S.A., subsidiary of Hellenic Industrial and Mining Investment Company of Athens, plans to build a 30 000 tpy ferrochromium plant near Valos on the east coast of Greece. The plant will use chromite concentrate produced from Hellenic's mine in northern Greece.

USES

While many minerals contain chromium, chromite is the only commercial ore mineral. The theoretical formula for chromite is $FeCr_2O_4$, although it usually contains several other elements and is represented by the general formula $(FeMn)O\ (CrAlFe)_2O_3$. Traditionally, chromite ores have been classified as metallurgical, chemical and refractory grades, according to the expected industrial end-uses. However, recent technological advances have allowed some degree of interchange in the usage of these three product categories with the result that the classification has become less meaningful. Current nomenclature is based upon chromite composition in addition to end-use. High-chromium ores, defined by high Cr/Fe ratios, are used for making ferrochromium for metallurgical applications. High-iron chromites, previously limited almost entirely to the production of chromium-based chemicals, are now finding growing usage in the production of low quality ferrochromium, refractories and foundry sands. High-aluminum chromites with relatively low iron and silica have application mainly for refractory purposes, primarily in the manufacture of magnesite-chromite and chromite-mangnesite brick.

TABLE 2. CANADA, CHROMIUM TRADE AND CONSUMPTION, 1970, 1975-1980

	Imports		Consumption[2]	
	Chromite[1]	Ferro-Chromium[2]	Chromite	Ferro-Chromium
	(tonnes)			
1970	27 619	20 814	56 212	28 356
1975	29 663	41 109	36 790	18 417
1976	39 864	22 493	30 783	32 177
1977	41 247	32 947	30 299	28 435
1978	28 497^{r}	30 432	27 472	36 572
1979	27 373	34 720	27 205	25 729
1980^{p}	28 373	41 364	..	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Chromium content. [2] Gross weight.
^{p} Preliminary; ^{r} Revised; .. Not available.

The principal use of chromium ferroalloys is in the production of stainless and heat-resistant steels. Most applications of stainless and heat-resistant steels are in corrosive environments such as petrochemical processing, high-temperature environments such as turbines and furnace parts, and consumer goods such as cutlery and decorative trim. Chromium is added to alloy and tool steels to increase their hardening ability and to improve mechanical properties such as yield strength. Superalloys containing chromium have a high degree of resistance to oxidation and corrosion at elevated temperatures and are used in jet engines, gas turbines and chemical process equipment. Chromium-containing castings are usually used in high-temperature applications.

The refractory industry uses chromite in the manufacture of refractory bricks, castables, mortars and ramming gun mixes. Chromite castables, mortars and gunning mixes are used for repairs and in the bonding and coating of basic bricks, or in areas where the separation of various types of bricks by a chemically neutral substance is desirable.

Refractories composed of both chromite and magnesite are used in furnaces wherever basic slags and dust are encountered, such as in the ferrous and nonferrous metal industries. In the ferrous industry, chrome-magnesite brick is used in basic open-hearth and electric furnaces. The phasing-out of open-hearth furnaces has led to a decline in the amount of chromite used as a refractory in the steel industry. However, this trend has been offset to a certain extent by an increase in electric furnace production and, overall, chromite refractory consumption in the steel industry is expected to stabilize in the next few years. In the nonferrous industry, chrome-magnesite brick is used mainly in converters. The increasing use of oxygen in oxygen-blowing converters, resulting in higher operating temperatures, has changed refractory requirements to a higher magnesite-content brick, thereby decreasing the consumption of chromite in this application. The glass industry uses chrome-magnesite brick in the reheating chambers of glass furnaces, while the kraft paper industry requires a dense chromite brick in recovery furnaces to resist chemical attack by spent liquors.

Chromium chemicals have a wide variety of applications in a number of industries. Most chromium chemicals are produced from sodium dichromate, which is manufactured directly from chemical-grade chromite. Chromium compounds are used as pigments, mordants and dyes in the textile industry; tanning agents for all types of leathers; and for chrome electroplating, anodizing, etching and dipping. Chromium compounds are also used as oxidants and catalysts in the manufacture of various products such as saccharin, in the bleaching and purification of oils, fats and chemicals; and as agents to promote water insolubility of various products such as glues, inks and gels.

TABLE 3. WORLD CHROMITE MINE PRODUCTION AND RESERVES, 1979 and 1980

Country	Mine Production		
	1979	1980^{e}	Reserves^{e}
	(000 tonnes, gross weight)		
Republic of South Africa	3 297	3 130	2 268 000
Philippines	562	530	3 000
Zimbabwe	542	500	998 000
Turkey	454	410	5 000
Finland	190	180	25 000
Other market economy countries	966	920	13 000
Centrally Planned Economies	3 513	3 310	20 000
World total	9 524	8 980	3 400 000

Source: U.S. Bureau of Mines, Mineral Commodity Summaries, 1981.

^{e} Estimated.

TECHNOLOGY

Union Carbide Corporation, and Joslyn Stainless Steels Division of Joslyn Mfg. & Supply Co., together developed the argon-oxygen decarburization (AOD) process, now widely used in the production of stainless and heat-resistant steels. It is essentially a refining step after the ferrochromium charge has been melted. Argon, an inert gas; and oxygen are added to the melt in order that carbon instead of chromium is preferentially oxidized. This allows the less expensive high-carbon ferrochrome to be used in place of high-priced. low-carbon ferrochrome. The overall advantages obtained are a lower cost for chromium additions as well as energy savings in the initial production of the ferroalloy. In Europe, a similar technology, known as the Creusot-Loire-Uddleholm (CLU) process, is being commercially developed by steelmakers.

The United States Bureau of Mines has developed a recycling technology to recover chromium from spent etching solution. Chromic acid is added to solutions used in finishing brass, etching printed circuit boards and preparing plastics for plating. After continued use the solution loses its etching ability as the initial trivalent chromium transforms to hexavalent chromium, a toxic substance that is subsequently treated and discarded. The Bureau of Mines' new electrolytic process allows 88 to 96 per cent of chromium in spent solutions to be regenerated. The process is currently being tested on different electroplating solutions.

OUTLOOK

Chromite is expected to remain in oversupply, with a corresponding weakness in prices, until ferrochromium producers can reduce their high inventories of chromite ores and concentrates. The demand for chromite ores has been depressed in part because ferrochromium producers have been operating at rates well below capacity due to weak stainless steel markets. At the same time, a recession in the world iron and steel industry has been a major factor in the reduced demand for chromium.

The medium- and long-term outlook is overshadowed by uncertainty in regards to supply continuity of South African chromium, largely because of the fragile political stability of this country. An interruption in supply from South Africa could have serious economic consequences in Canada and the rest of the western world, as other producing countries could not immediately increase chromium production to fill the gap left by the sudden loss of South African supply. A prolonged interruption would probably result in real physical shortages.

PRICES

Chromium prices published by **Metals Week**

	December 31, 1979	December 31, 1980
	($US)	
Chromium ore, dry basis, fob shipping point		
Transvaal 44% Cr_2O_3, no ratio (per tonne)	54.00-58.00	51.00-55.00
Turkish 48% Cr_2O_3, 3:1 ratio (per tonne)	110.00	110.00
Chromium metal		
Electrolytic 99.1% Cr, fob shipping point (per kg)	1.59	1.93
	(¢US)	
Ferrochromium, fob shipping point (per kg Cr content)		
High carbon 66-70% Cr, 5.0-6.5% C	99.21-116.84	106.92-114.64
Imported 60-65% charge chrome	105.82-114.64	101.41-110.23
Low carbon 67-73% Cr, 0.025% C	209.44	220.46

fob - Free on board

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
32900-1	Chrome ore	free	free	free	free

TARIFFS (Cont'd.)

CANADA (Cont'd.)

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
34700-1	Chromium metal in lumps, powder, ingots, blocks or bars, and scrap alloy metal containing chromium for use in alloying purposes	free	free	free	free
37506-1	Ferrochrome	free	5	5	free
92821-1	Chromium oxides and hydroxides	free	14.7	25	free
	With the following exceptions: For use in the manufacture of artificial resins and plastics	free	free	25	free
	For use in the manufacture of additives for heating, lubricating and fuel oils	free	5	25	free
92821-2	Chromium trioxide for use in the manufacture of galvanized and tin plated steel	free	free	25	free
92838-8	Chromium potassium sulphate	free	free	10	free
92838-9	Chromium sulphate, basic	free	free	10	free

MFN Reductions under GATT (effective January 1 of year given)

Item No.	1980	1981	1982	1983	1984	1985	1986	1987
37506-1	5.0	5.0	4.8	4.7	4.5	4.3	4.2	4.0
92821-1	14.7	14.4	14.1	13.8	13.4	13.1	12.8	12.5

UNITED STATES

Item No.		
473.10-20	Chrome colours	4.8%
601.15	Chrome ore	Remains free
606.24	Ferrochromium, containing over 3% by weight of carbon	1.9%
632.86	Chromium alloys, unwrought, 96-99% silicon	9.0%

		1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
420.98	Chromate and dichromate	2.8	2.8	2.7	2.7	2.6	2.5	2.5	2.4
531.21	Chrome refractory and heat insulating bricks	11.8	11.0	10.3	9.6	8.8	8.1	7.3	6.6
606.22	Ferrochromium, not containing over 3% by weight of carbon	4.0	4.0	3.9	3.7	3.6	3.4	3.3	3.1

TARIFFS (Cont'd.)

UNITED STATES (Concl'd.)

		1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
632.18	Chromium metal, unwrought (duty on waste and scrap suspended)	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
632.88	Chromium alloys, unwrought, not otherwise specified	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated (1980), USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241.

Clays and Clay Products

G.O. Vagt

Clays are a complex group of industrial minerals, each generally characterized by different mineralogy, occurrence and uses. All are natural, earthy, fine-grained minerals of secondary origin, composed mainly of a group of hydrous aluminum silicates and may contain iron, alkalis and alkaline earths. The clay minerals, formed by the chemical weathering or alteration of aluminous minerals such as feldspar and mica, are generally classified into three major groups based on detailed chemistry and crystalline structure - the kaolinite group, the smectite group (montmorillonite group of some usages) and the illite group. Clay deposits suitable for the manufacture of ceramic products may include non-clay minerals such as quartz, calcite, dolomite, feldspar, gypsum, mica, iron-bearing minerals and organic matter. The non-clay minerals may or may not be deleterious, depending upon individual amounts present and on the particular application for which the clay is intended.

The commercial value of clays, and of shales that are similar in composition to clays, depends mainly on their physical properties - plasticity, strength, shrinkage, vitrification range and refractoriness, fired colour, porosity and absorption - as well as on proximity to growth centres in which clay products will be consumed.

Brick and drain tile manufacturing included in the heavy clay products category accounts for nearly 70 per cent of the total value of output by clay products manufacturers using material from domestic sources.

USES, TYPE AND LOCATION OF CANADIAN DEPOSITS

Common clays and shale. Common clays and shales are the principal raw materials available from Canadian deposits for the manufacture of clay products. They are found in all parts of Canada, but deposits having excellent drying and firing properties are generally scarce and new deposits are continually being sought.

The clay minerals in common clays and shales are chiefly illitic or chloritic. Suitable common clays and shales are utilized in the manufacture of heavy clay products such as common brick, facing brick, structural tile, partition tile, conduit tile, quarry tile and drain tile. Some Canadian common clays are mixed with stoneware clay for the manufacture of facing brick, sewer pipe, flue lining and related products. The raw materials utilized in the heavy clay industry usually contain up to 35 per cent quartz. If the quartz, together with other nonplastic materials, exceeds this percentage, the plasticity of the clay is reduced and the quality of the ware is lowered. If calcite or dolomite is present in sufficient quantities, the clay will fire buff and the fired strength and density will be adversely affected.

Most of the surface deposits of common clays in Canada are the result of continental glaciation and subsequent stream transport. Such Pleistocene deposits are of interest to the ceramic industry and include stoneless marine and lake sediments, reworked glacial till, interglacial clays and floodplain clays.

TABLE 1. CANADA, PRODUCTION OF CLAY AND CLAY PRODUCTS FROM DOMESTIC SOURCES, 1978-80

	1978	1979	1980P
		($000)	
Production from domestic sources, by provinces			
Newfoundland	592	659	778
Nova Scotia	4,700	9,429	6,023
New Brunswick	2,300	2,356	2,667
Quebec	17,220	18,503	17,511
Ontario	59,667	63,144	59,527
Manitoba	2,000	3,504	1,139
Saskatchewan	3,146	3,148	3,290
Alberta	11,200	12,556	11,581
British Columbia	8,810	8,227	11,750
Total Canada	109,635	121,526	114,266
Production[1] from domestic sources, by products			
Clay, fireclay and other clay	...	...	...
Brick - soft and stiff mud process and dry press	80,508	87,471	75,662
Drain tile	3,205	4,141	3,582
Sewer pipe	(2)	(2)	(2)
Flue linings	2,510	3,018	2,611
Pottery glazed or unglazed (including coarse earthenware, stoneware and all pottery)	(2)	(2)	(2)
Other products	15,782	15,989	22,976
Small establishments not reporting detail	7,630	10,907	9,435
Total	109,635	121,526	114,266

Source: Statistics Canada.

[1] Producers' shipments. Distribution for 1980 estimated by Mineral Census Section, Mineral Policy Sector. (2) Included in "Other products".
P Preliminary; ... Figures not appropriate or not applicable.

The common shales provide the best source of raw material for making brick. In particular, those found in Cambrian, Ordovician and Carboniferous rocks in eastern Canada, and Jurassic, Cretaceous and Tertiary rocks in western Canada, are utilized by the ceramic industry.

China Clay (Kaolin). China clay is a high-quality white, or nearly white, clay formed from the decomposition of crystalline rocks such as granite.

None of the crude kaolins known to exist in Canada have been developed, primarily because of beneficiation problems and the small size of some deposits. In the crude material the percentage of kaolinite frequently is small and has made the removal of impurities from Canadian kaolins difficult.

China clay is used primarily as a filler and coater in the paper industry, a raw material in ceramic products, and a filler in rubber in other products. In the ceramic industry china clay is used as a refactory raw material. In prepared whiteware bodies such as wall tile, sanitaryware, dinnerware, pottery and electrical porcelain, quantities of nepheline syenite, silica, feldspar and talc are used as well.

In southern Saskatchewan, deposits of sandy kaolin occur near Wood Mountain, Fir Mountain, Knollys, Flintoft and other localities. Despite considerable work, no satisfactory method of producing a good commercial kaolin from these deposits has been developed.

A deposit of refractory clay which is very plastic to very sandy, and is similar to a secondary china clay, occurs along the Fraser River near Prince George, British Columbia. This material has been investigated as a source of kaolin, as a fire clay and as a raw material for facing brick.

TABLE 2. CANADA, IMPORTS AND EXPORTS OF CLAY, CLAY PRODUCTS AND REFRACTORIES, 1979 and 1980

	1979		1980P	
	(tonnes)	($000)	(tonnes)	($000)
Imports				
Clays				
Bentonite	612 747	20,865	469 292	18,011
Drilling mud	44 213	12,534	32 159	7,437
China clay, ground or unground	273 422	19,652	254 354	21,836
Fire clay, ground or unground	52 244	2,810	39 335	3,080
Clays, ground or unground nes	119 566	6,674	109 563	7,202
Clays and earth, activated	15 026	7,063	17 554	8,900
Subtotal, clays	1 117 218	69,598	922 257	66,466
Clay Products	(M)		(M)	
Brick-building, glazed	2 045	336	1 708	284
Brick-building, nes	76 882	4,224	23 128	3,506
Building blocks and hollow tiles	..	2,458	..	2,807
Clay bricks, blocks and tiles, nes	..	5,431	..	5,991
Ceramic tiles	(m^2)		(m^2)	
under 2 1/2" x 2 1/2"	1 372 577	6,896	1 208 239	8,267
over 2 1/2" x 2 1/2"	5 737 519	31,646	6 964 607	42,543
Subtotal, brick, blocks, tile	..	50,991	..	63,398
Tableware, ceramics	..	89,729	..	122,999
Porcelain, insulating, fitting	..	12,903	..	14,163
Pottery settings and firing supplies	..	872	..	1,057
Subtotal, porcelain pottery	..	103,504	..	138,219
Refractories				
Firebrick				
Alumina	27 831	17,314	26 336	18,945
Chrome	1 511	1,226	1 008	781
Magnesite	15 876	11,071	19 183	13,923
Silica	4 896	1,510	4 776	2,263
nes	177 024	46,553	184 904	55,152
Refractory cements and mortars	..	10,996	..	12,605
Acid-proof brick	..	159	..	222
Crude refractory materials, nes	9 568	2,586	12 855	2,923
Grog (refractory scrap)	12 544	1,212	19 720	1,758
Refractories, nes	..	6,389	..	9,523
Subtotal refractories	..	99,016	..	118,095
Total clay, clay products and refractories	..	323,109	..	386,178
Imports				
By main countries				
United States	..	174,366	..	190,651
United Kingdom	..	63,900	..	82,841
Japan	..	19,761	..	31,675
Italy	..	23,619	..	27,801
West Germany	..	10,558	..	11,462
Spain	..	5,181	..	9,387
Greece	..	5,134	..	5,055
South Korea	..	3,183	..	3,361
France	..	3,242	..	3,355
Philippines	..	1,534	..	2,500
Taiwan	..	875	..	2,043
Brazil	..	596	..	1,592
China	..	452	..	1,389
Other	..	10,708	..	13,066
Total	..	323,109	..	386,178

TABLE 2. (cont'd)

	1979		1980P	
	(tonnes)	($000)	(tonnes)	($000)
Exports				
Clays, ground and unground	1 311	134	1 116	99
Clay products	(M)		(M)	
Building brick, clay	9 537	1,865	7 585	1,747
Clay bricks, blocks, tiles, nes	..	1,546	..	1,231
Subtotal, bricks, blocks, tiles	..	3,411	..	2,978
High-tension insulators and fittings	..	3,599	..	3,909
Tableware, nes	..	6,841	..	9,985
Subtotal, porcelain tableware	..	10,440	..	13,894
Refractories				
Fire brick and similar shapes	74 303	32,884	67 882	31,716
Crude refractory materials	1 023 734	2,310	803 906	2,027
Refractory nes	..	12,077	..	13,050
Subtotal refractories	..	47,271	..	46,793
Total clays, clay products and refractories	..	61,256	..	63,764
By main countries				
United States	..	31,663	..	31,937
Venezuela	..	8,949	..	7,514
Indonesia	..	1,580	..	2,462
Mexico	..	3,581	..	1,473
Dominican Republic	..	1,653	..	1,181
Zambia	..	809	..	1,155
United Kingdom	..	753	..	1,077
Australia	..	628	..	868
Colombia	..	538	..	836
South Africa	..	328	..	601
Saudi Arabia	..	1,913	..	569
Ecuador	..	617	..	343
Other countries	..	8,244	..	13,748
Total	..	61,256	..	63,764

Source: Statistics Canada.

P Preliminary; .. Not available; nes Not elsewhere specified; M = thousands; m^2 = square metres.

Various kaolinitic-rock deposits have been investigated in Manitoba. The reported deposits are principally in the northwest at Cross Lake and Pine River, on Deer Island (Punk Island) and Black Island in Lake Winnipeg, and at Arborg.

Several companies have shown considerable interest in Quebec's kaolin-bearing deposits although the deposits, in general, contain an excessive amount of quartz and iron minerals. Kaolin-bearing rock occurs at St-Rémi-d'Amherst, Papineau County; Brébeuf, Terrebonne County; Point Comfort, on Thirty-one Mile Lake, Gatineau County; and Chateau-Richer, Montmorency County.

Extensive deposits of kaolin-silica sand mixtures occur in northern Ontario along the Missinaibi and Mattagami rivers. Distance from markets and the difficult terrain and climate of the area have hindered development, although some encouraging results were obtained.

Ball Clay. Ball clays are a very fine grained, sedimentary kaolinitic type of clay with unfired colours ranging from white to various shades of grey depending on the amount of carbonaceous material present. They are extremely refractory materials and have less alumina and more silica than kaolin.

Ball clays obtained in Canada are mineralogically similar to high-grade, plastic fire clay and are composed principally of fine-particle kaolinite, quartz, illite and mica. These clays are known to occur in the Whitemud Formation of southern Saskatchewan. Good-quality deposits are present at Willows, Readlyn, Big Muddy Valley, Blue Hills, Willow Bunch, Flintoft and in other areas. Clay from the Willows area has been used for many years in the potteries at Medicine Hat and Vancouver; however, the lack of proper quality control, the distance from large markets and lack of reserves have been the principal disadvantages affecting the widespread use of this material. Some ball clays from the Flintoft area are used for white-to-buff facing brick and for household pottery and crocks.

Fire Clay. Fire clays contain high percentages of alumina and silica. They may be sedimentary or residual in origin, plastic or nonplastic and are composed mainly of kaolinite.

Canadian fire clays are used principally for the manufacture of medium- and high-duty firebrick and refractory specialties. Known Canadian fire clays are not sufficiently refractory for the manufacture of super-duty refractories without the addition of some very refractory material such as alumina.

Various grades of good-quality fire clay occur in the Whitemud Formation in southern Saskatchewan and on Sumas Mountain in British Columbia. Some fire clay from the Sumas deposit is exported to the United States, and a small quantity is used at plants in Vancouver.

Fire clay, associated with lignite as well as with kaolin-silica sand mixtures, occurs in the James Bay watershed of northern Ontario along the Missinaibi, Abitibi, Moose and Mattagami rivers.

At Shubenacadie, Nova Scotia, some seams of clay are sufficiently refractory for medium-duty refractories. Research has indicated that these deposits may be suitable for production of ladle brick. Clay from Musquodoboit, Nova Scotia has been used by a few foundries in the Atlantic provinces, and the properties and extent of this clay were investigated by the Nova Scotia Department of Mines.

Ontario and Quebec have no producing domestic sources of fire clay and import most of their requirements from the United States.

Stoneware Clay. Stone clays are similar to low-grade plastic clays. They range from commercially inferior material through semi-refractory to firebrick clays.

Stoneware clays are used extensively in the manufacture of sewer pipe, flue liners, facing brick, pottery, stoneware crocks and jugs, and chemical stoneware.

The principal source of stoneware clay in Canada is the Whitemud Formation in southern Saskatchewan and southeastern Alberta. The Eastend area in Saskatchewan was formerly the source of much of the clay used at Medicine Hat. Stoneware clay pits are presently located in the Alberta Cypress Hills, southeast of Medicine Hat, and at Avoniea, Saskatchewan. Stoneware clays occur on Sumas Mountain, near Abbotsford, British Columbia. These clays are used in the manufacture of sewer pipe, flue lining, facing brick and tile.

In Nova Scotia, stoneware clays occur at Shubenacadie and Musquodoboit. The Shubenacadie clays are used principally for the manufacture of buff facing brick. Other similar deposits occur at Swan River, Manitoba, where some buff brick has been manufactured, Kergwenan, Manitoba and in British Columbia at Chimney Creek Bridge, Williams Lake, Quesnel and near the Alaska Highway at Coal River. Quebec and Ontario import stoneware clay from the United States for manufacture of facing brick and sewer pipe.

CANADIAN INDUSTRY AND DEVELOPMENTS

The value of clay products produced from domestic sources in 1980 declined slightly from the previous year. Clay products manufacturers using imported clays include those who are primarily involved in the manufacture of products such as electrical porcelains, glazed floor and wall tiles, pottery, chinaware and sanitary ware. The value of shipments of this group of products during 1979 increased slightly. The value of imported clay products was about 33 per cent higher in 1980.

TABLE 3. CANADA, SHIPMENTS OF CLAY PRODUCTS PRODUCED FROM IMPORTED CLAY[1], 1977-79

	1977	1978	1979P
		($000)	
Electrical porcelains	20,705	..	..
Glazed floor and wall tile	8,966	..	..
Sanitaryware	..	..	..
Pottery, art and decorative ware	..	..	..
All other products	32,635	..	..
Total	62,306	64,767	71,398

Source: Statistics Canada.

[1] Does not include refractories.
P Preliminary; .. Not applicable or not available.

IXL Industries Ltd. of Medicine Hat, Alberta completed the first part of an expansion at its Redcliff pressed brick plant when a second tunnel kiln came on stream to make a pressed and oversize Giant Brick. It is expected that upgraded manufacturing facilities to be completed in 1981 will allow production of 35 to 40 million brick equivalents per year.

WORLD REVIEW

United States mine production of clays in 1980 was about 44 million t valued at about $900 million compared to the 1979 level of approximately 50 million t valued at $846 million.

Demand for clays in the United States is expected to increase at annual rates of between 2 and 4 per cent through 1990, however, continued growth of the energy intensive clay-based industries could be severely impeded by persistent energy problems and lower construction activity. Adequate reserves of high quality clays of all types, together with possession of clay-processing technology, assure the United States a position as a major world supplier of clays.

In French Guiana kaolin was being tested for paper filling and coating uses, and in Guyana a study is being planned to evaluate kaolin reserves in the Ituni area. In Pakistan kaolin deposits are the subject of a feasibility study and in Portugal kaolin deposits are being explored.

OUTLOOK

The clay and clay products industry will continue to place increasing emphasis on improving energy efficiencies. The Canadian brick and tile industry made a commitment to reduce energy consumption by 23 per cent between 1973-74 and 1985. This goal should be easily met based on trends to date. Research and development may be warranted to utilize lower cost sources of renewable energy in the form of solid fuel. Pulverized coal could also be used where availability and cost effectiveness allow.

Demand for high-grade, super-duty refractories is expected to accelerate when the economy strengthens. Steel processes such as the basic oxygen furnace, pressure pouring and continuous casting, represent relatively new refractory requirements. New

TABLE 4. CANADA, SHIPMENTS OF REFRACTORIES, 1977-79

	1977		1978		1979P	
	(tonnes)	($000)	(tonnes)	($000)	(tonnes)	($000)
Castables	21 530	6,495	29 835	10,170	36 879	14,983
Firebrick and similar shapes	(1)	(1)	94 651	43,976	141 517	74,790
Cement, mortars, castables, plastics, etc.	32 465	7,789	45 918	12,869	32 827	9,751
All other products	..	55,886	..	30,330	..	40,208
Total	..	70,170	..	97,345	..	139,732

Source: Statistics Canada.
(1) Confidential included with "All other products".
P Preliminary; .. Not applicable or not available.

TABLE 5. CANADA, CLAY AND CLAY PRODUCTS, PRODUCTION AND TRADE 1970, 1975-80

Year	Production			Refractory Shipments[1]	Imports	Exports
	Domestic Clays	Imported Clays	Total			
			($ million)			
1970	51.8	33.6	85.4	42.3	81.2	15.6
1975	78.4	59.1	137.5	65.0	177.4	25.1
1976	98.5	59.0	157.5	65.0	178.8	25.2
1977	103.4	62.3	165.7	70.2	220.0	30.6
1978	109.6	64.8	174.4	97.3	252.0	43.0
1979	121.5	71.4	192.9	139.7	323.1	61.2
1980P	114.3	..	..	..	386.2	63.8

Source: Statistics Canada.

[1] Includes fire brick and similar shapes, refractory cements, mortars, castables, plastics, etc., plus all other product shipped.
P Preliminary; .. Not available.

TABLE 6. CANADA, CONSUMPTION (AVAILABLE DATA) OF CHINA CLAY, BY INDUSTRIES, 1978 AND 1979

	1978	1979P
	(tonnes)	
Paper and paper products[1]	145 658	160 807
Ceramic products	9 351	9 847
Paint and varnish	4 248	9 241
Rubber and linoleum	4 319	7 108
Other products[2]	38 439	20 978
Total	202 015	207 981

Source: Energy, Mines and Resources Canada.

[1] Includes paper and paper products and paper pulp. [2] Includes refractory brick mixes, cements, glass fibre and wools, adhesives, foundry, wire and cable and other miscellaneous products.
P Preliminary.

products and designs have also been dictated by changes in reducing atmospheres in the chemical and petrochemical industry, by increased demand for high-purity glass and by the need for more economical production of ceramics.

Clay and shale, like other low-cost construction materials, must be produced near the heavily populated areas. This necessary feature of the industry will continue to produce increasingly complex problems related to rising land costs, land use conflicts, environmental control requirements, and cost of land rehabilitation. The situation is particularly acute in southwestern Ontario where suitable reserves of shales and other construction materials are being depleted with few prospects for the opening of new pits and quarries under present controls.

BENTONITE AND FULLER'S EARTH

Bentonite is covered in a separate annual mineral review.

Fuller's earth is primarily a calcium montmorillonite clay characterized by natural bleaching and absorbent properties; it is similar to nonswelling bentonite. The terminology is confusing and bentonite and fuller's earth may not necessarily be separated in world trade and production statistics by country.

PRICES

($ per short ton)

United States clay prices, according to **Chemical Marketing Reporter**, December 29, 1980.

	($ per short ton)
Ball clay	
Domestic, crushed, moisture-repellent, bulk carlots, fob Tennessee	8.00-11.25
Imported lump, bulk, fob Great Lakes ports	40.50
Imported, airfloated, bags, carlots Atlantic ports	70.00
China clay (koalin)	
Water washed, fully calcined, bags, carlots, fob Georgia	175.00-208.00
Uncalcined, No. 1 coating, same basis, bulk	76.00
Dry-ground, airfloated soft, same basis	25.00

TARIFFS

CANADA

Item No.		British Preferential (%)	Most Favoured Nation (%)	General (%)	General Preferential (%)
29500-1	Clays, including china clay, fire clay and pipe clay not further manufactured than ground	free	free	free	free
29525-1	China clay	free	free	25	free
28100-1	Firebrick containing not less than 90 per cent silica; magnesite firebrick or chrome firebrick; other firebrick valued at not less than $100 per 1,000, rectangular shaped, not to exceed 100 x 25 in.^{3} for use in kiln repair or other equipment of a manufacturing establishment	free	free	free	free
28105-1	Firebrick, nop, of a class or kind not made in Canada, for use in construction or repair of a furnace, kiln, etc.	free	free	15	free
28110-1	Firebrick, nop	5	9.6	22.5	5
28200-1	Building brick and paving brick	9.4	9.4	22.5	6.5
28205-1	Manufactures of clay or cement, nop	11.9	11.9	22.5	7.5
28210-1	Saggars, hillers, bats and plate setters, when used in the manufacture of ceramic products	free	free	free	free
28300-1	Drain tiles, not glazed	free	16.6	20	free
28400-1	Drain pipes, sewer pipes and earthenware fittings therefor; chimney linings or vents, chimney tops and inverted blocks glazed or unglazed, nop	15	18.9	35	12.5
28405-1	Earthenware tiles, for roofing purposes	free	16.6	35	free
28415-1	Earthenware tiles, nop	12.5	19.1	35	12.5

TARIFFS (cont'd)

Item No.		British Preferential (%)	Most Favoured Nation (%)	General (%)	General Preferential (%)
28500-1	Tiles or blocks of earthenware or of stone prepared for mosaic flooring	15	19.1	30	12.5
28600-1	Earthenware and stoneware, viz: demijohns, churns or crocks, nop	18.9	18.9	35	12.5
28700-1	All tableware of china, porcelain, semi-porcelain or white granite, excluding earthenware articles	free	15	35	free
28705-1	Articles of chinaware, for mounting by silverware manufacturers	12.5	16.6	22.5	11
28710-1	Undecorated tableware of china, porcelain, semi-porcelain for use in the manufacture of decorated tableware	free	9.6	35	free
28800-1	Stoneware and Rockinghamware and earthenware, nop	15.7	18.9	35	12.5
28805-1	Chemical stoneware	free	9.6	35	free
28810-1	Hand forms of porcelain for manufacture of rubber gloves	free	10	35	free
28900-1	Baths, bathtubs, basins, closets, closet seats and covers, closet tanks, lavatories, urinals, sinks and laundry tubs of earthenware, stone, or cement, clay or other material, nop	12.5	15	35	10

MFN Reductions under GATT (effective January 1 of year given)

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
28110-1	Firebrick, nop	9.6	9.2	8.8	8.4	8.0	7.6	7.2	6.8
28200-1	Building brick and paving brick	9.4	8.8	8.1	7.5	6.9	6.3	5.6	5.0
28205-1	Manufactures of clay or cement, nop	11.9	11.4	10.8	10.3	9.7	9.1	8.6	8.0
28300-1	Drain tiles, not glazed	16.6	15.7	14.8	13.9	12.9	12.0	11.1	10.2
28400-1	Drain pipes, sewer pipes and earthenware fittings therefor; chimney linings or vents, chimney tops and inverted blocks glazed or unglazed, nop	18.9	17.8	16.7	15.7	14.6	13.5	12.4	11.3
28405-1	Earthenware tiles, for roofing purposes	16.6	15.7	14.8	13.9	12.9	12.0	11.1	10.2
28415-1	Earthenware tiles, nop	19.1	18.1	17.2	16.3	15.3	14.4	13.4	12.5
28500-1	Tiles or blocks of earthenware or of stone prepared for mosaic flooring	19.1	18.1	17.2	16.3	15.3	14.4	13.4	12.5

TARIFFS (cont'd.)

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
28600-1	Earthenware and stoneware, viz: demijohns, churns or crocks, nop	18.9	17.8	16.7	15.7	14.6	13.5	12.4	11.3
28700-1	All tableware of china, porcelain, semi-porcelain or white granite, excluding earthenware articles	15.0	15.0	15.0	15.0	14.6	13.5	12.4	11.3
28705-1	Articles of chinaware, for mounting by silverware manufacturers	16.6	15.7	14.8	13.9	12.9	12.0	11.1	10.2
28710-1	Undecorated tableware of china, porcelain, semi-porcelain for use in the manufacture of decorated tableware	9.6	9.2	8.8	8.4	8.0	7.6	7.2	6.8
28800-1	Stoneware and Rockinghamware and earthenware, nop	18.9	17.8	16.7	15.7	14.6	13.5	12.4	11.3
28805-1	Chemical stoneware	9.6	9.2	8.8	8.4	8.0	7.6	7.2	6.8
28900-1	Baths, bathtubs, basins, closets, closet seats and covers, closet tanks, lavatories, urinals, sinks and laundry tubs of earthenware, stone, or cement, clay or other material, nop	15.0	15.0	15.0	15.0	14.6	13.5	12.4	11.3

UNITED STATES

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
					(¢ per long ton)				
521.71	Common blue clay and other ball clays, not beneficiated	41.5	41.0	40.5	40.0	39.5	39.0	38.5	38.0
521.74	Common blue clay and other ball clays wholly or partly beneficiated	84.0	83.0	82.0	81.0	80.0	79.0	78.0	77.0
					¢ per lb. + % ad valorem				
521.87	Clays artifically activated with acid or other material	0.04¢ +5.6%	0.04¢ +5.1%	0.03¢ +4.7%	0.02¢ +4.3%	0.02¢ +3.8%	0.01¢ +3.4%	0.01¢ +2.9%	- +2.5%

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated 1980, USITC Publication 1011, U.S. Federal Register, Vol. 44, No. 241.

Note: In addition to the above tariffs various duties are in existence on manufactured clay products, viz., brick pottery, artware, etc. nop Not otherwise provided for.

Coal and Coke

J.A. AYLSWORTH AND M. SEATON

Coal continued to receive attention in Canada and around the world in 1980 as demand grew and forecasts predicted significant growth in coal use in the 1980s and 1990s. Canada's coal industry expanded in 1980 as production, consumption and export figures were up over 1979 levels. Domestic utilization of coal grew as three new coal-fired thermal generating stations came on-stream and several other new units neared completion. In western Canada construction of new mines and pre-construction work on potential new mines continued. Several major new export contracts were in the final stages of negotiation.

International attention was focussed on coal in May when the World Coal Study - **"Coal - Bridge to the Future"** was released. This study predicted a major increase in thermal coal demand in the 1980s and 1990s as energy users will be forced to adjust to the higher prices and uncertainties developing from the international oil supply situation. The report noted that large resources of coal relative to other energy fuels, and the potential convertibility of coal to liquid and chemical feedstocks ensure that coal will supply a much larger share of the world's energy needs in the coming decades. World coal output may have to grow by 2.5 to 3 times to supply the additional energy that will be required in the coming decades. If this is to be achieved, world thermal coal trade will have to increase by 10- to 15-fold. In addition coking coal trade is forecast to increase by significant amounts during this same period.

Coal was also singled out as an important energy fuel of the future in the final communiqué of the Venice Summit in June 1980. The communiqué recommended greater reliance on non-oil fuels to satisfy a growing proportion of the world's energy needs related to future economic growth. This will result in large increases in coal use in combination with greater use of nuclear energy, solar and other forms of renewable energy. Summit members called for a doubling of world coal production and use by the early 1990s along with an expansion of coal handling infrastructure facilities in both coal exporting and importing countries.

GOVERNMENT COAL INITIATIVES AND RELATED DEVELOPMENTS

In September, the Minister of Energy, Mines and Resources released a "Discussion Paper on Coal 1980". This paper described the main characteristics of the Canadian coal system which, largely because of the geographical distribution of the coal-producing and -consuming districts, tends to be quite different in many important respects from the situation in other major coal-producing and coal-using nations. The paper set out the role coal could play in the coming years and probed the opportunities and difficulties associated with its increased use. Its main objective was to identify and illuminate the more important choices facing Canada in the coal field.

Also in September, the Minister released a statement concerning the production and possible exports of synthetic fuels. The statement announced "that the federal government is prepared to examine proposals for the production of liquids from coal in Canada on a case-by-case basis" and is "prepared to negotiate terms for the export of the liquid product to other nations as exceptions to the usual conditions administered by the National Energy Board (NEB)". Technological and other benefits, including involvement in the ownership and supply of materials, would have to accrue to Canada in any such developments. Both Japanese and European concerns have expressed interest in looking at the possibilities of joint participation in such projects in Canada.

Late in 1980, the federal government released a National Energy Program (NEP) which included several initiatives that will result in greater coal utilization in the provinces of Nova Scotia and New Brunswick. A Utility Off-Oil Fund is to be established with an initial funding of $175 million "to finance on a grant basis up to 75 per cent of the cost of environmentally acceptable conversions of oil-fired electricity plants to coal". Conversion of the Coleson Cove plant in New Brunswick and the Tufts Cove plant in Nova Scotia would be possible under such a program. As an aid to greater utilization of eastern Canadian coal and Atlantic economic development, the Government of Canada also agreed to make available sufficient funds "for exploratory tunneling and assessment of the technical and economic feasibility of the Donkin Mine" near Sydney, Nova Scotia.

Through the National Energy Program it was also announced that $4 million would be made available over the next four years for coal research and development expenditures, with priorities on "health and mine safety, coal beneficiation, combustion and utilization research, establishment of a Coal Testing Institute, and establishment of a continuing program in mining technology". In addition, the federal government announced that it would contribute $50 million over a three-year period (with the provision for a further $100 million) to help facilitate the utilization of Cape Breton coals in the supply of energy in Nova Scotia in particular and in the Maritimes in general.

STATISTICAL REVIEW

Canadian production of clean coal rose to a record level in 1980 of 36.7 million tonnes (t), up from 33.0 million t in 1979 (Table 1). The value of coal production also reached a record level of $943 million, a 13 per cent increase over 1979s level of $836 million.

Bituminous coal production rose to 20.1 million t, up 9 per cent from the 1979 level of 18.4 million t (Table 2). Alberta, the only province producing sub-bituminous coal, registered a gain of 11 per cent over 1979 as production rose to 10.5 million t. Lignite production in Saskatchewan rose 18 per cent to 5.9 million t. The average value of all types of coal increased in 1980, with bituminous coal reaching $42.42 per t, sub-bituminous coal $5.25 per t and lignite $5.42 per t, compared with $41.80, $4.55 and $4.34 per t respectively for 1979.

In 1980 Alberta was the leading coal-producing province in terms of volume, with a clean or saleable output of 17.4 million t. British Columbia produced 10.2 million t, Saskatchewan 5.9 million t, Nova Scotia 2.7 million t and New Brunswick 439 000 t.

The volume of imported coal in 1980 exceeded Canada's coal exports. Imports were 15.8 million t and exports 15.3 million t. The value of imports reached $954 million while exports were valued at $923 million. (see Tables 6 and 10).

Domestic coal consumption showed a marked increase in 1980. Consumption of thermal coal reached 27.7 million t in 1980, up 13 per cent over 1979, while coal utilization for general industrial and other use grew to 2.3 million t up from 1.9 million t in 1979. Consumption of coking coal totalled 7.2 million t in 1980, representing a 9 per cent decrease from the 1979 level of 7.8 million t. Domestic coals accounted for 13 per cent or .9 million of the 7.2 million t of the coking coal used in Canada in 1980.

TRADE

Exports

In 1980 the volume of Canadian coal exports rose to 15.3 million t, up 12 per cent from the 1979 figure of 13.7 million t. The value of exports reached a record level of $923 million in 1980, up nearly 18 per cent over 1979.

Again in 1980, Japan was the leading importer of Canadian coal, receiving 73 per cent of all exports. Four other Asian countries received, 12 per cent; four Latin American countries, 6 per cent and nine European countries, 9 per cent. In terms of volume, 11.1 million t were exported to Japan, 1.8 million t went to other Asian countries and 1.4 million t to markets in Europe. Exports to markets other than Japan grew by 29 per cent to 4.1 million t in 1980, up from 3.2 million t in 1979.

TABLE 1. SUMMARY OF COAL SUPPLY BY TYPE AND VALUES, 1976-80

	1976		1977		1978		1979		1980	
	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)	(000 t)	($000)
DOMESTIC[1]										
Bituminous										
Nova Scotia	2 000	57,756	2 164	81,733	2 650	116,322	2 157	103,279	2 726	132,750
New Brunswick	297	5,882	278	6,168	395	10,042	310	10,260	439	17,269
Alberta	4 583	206,919	4 274	191,026	5 115	212,616	5 349	190,059	6 830	246,771
British Columbia	7 509	299,870	8 585	339,686	9 061	379,489	10 616	466,801	10 156	457,959
Total	14 389	570,427	15 301	623,613	17 142	718,469	18 432	770,399	20 151	854,749
Sub-bituminous										
Alberta	6 409	25,000	7 902	29,962	8 278	36,135	9 569	43,562	10 542	55,402
Lignite										
Saskatchewan	4 677	13,039	5 478	20,762	5 058	21,520	5 012	21,770	5 971	32,381
Total	25 475	608,466	28 681	674,337	30 477	776,124	33 013	835,731	36 664	942,532
IMPORTED[2]										
Bituminous & Anthracite Briquettes	14 622	686,473	15 439	772,000	14 119	789,704	17 524	1,033,703	15 860	953,998
Total Coal Supply	40 097	1,294,939	44 120	1,446,337	44 596	1,565,828	50 537	1,869,434	52 524	1,896,530

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] fob mines; [2] Value at US ports of exit.

TABLE 2. CANADA, COAL PRODUCTION BY TYPES, PROVINCES AND TERRITORIES, 1979 AND 1980

	1979			1980		
	Surface	Underground	Total	Surface	Underground	Total
			(000 tonnes)			
Bituminous						
Nova Scotia	152	2 574	2 726	41	2 116	2 157
New Brunswick	439	-	439	310	-	310
Alberta	6 058	772	6 830	4 461	888	5 349
British Columbia	9 648	508	10 156	9 990	626	10 616
Sub-Total	16 297	3 854	20 151	14 802	3 630	18 432
Sub-bituminous						
Alberta	10 542	-	10 542	9 553	16	9 569
Lignite						
Saskatchewan	5 971	-	5 971	5 012	-	5 012
Total production	32 810	3 854	36 664	29 367	3 646	33 013

Sources: Statistics Canada; Energy, Mines and Resources Canada.
- Nil.

Metallurgical and coking coal exports are forecast to double in size and mature through market diversification during the next decade, while thermal coal exports may increase at even greater rates in the 1980s. A rapidly growing international market in steam coal is developing in response to the phenomena of rising petroleum prices, planned diversification of energy supplies on the part of coal importers, and increased availability of competitively priced thermal coal.

Imports

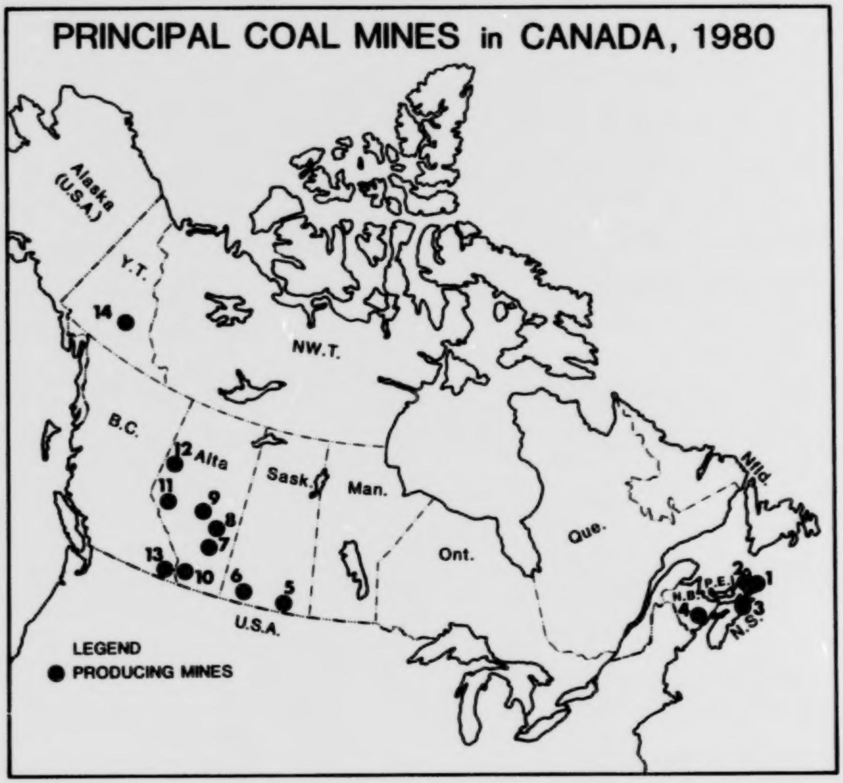
Imports of coal into Canada during 1980 were 15.8 million t. Thermal coal imports from the United States to Ontario totalled 8.2 million t, down 16 per cent from the 1979 level of 9.8 million t. Imports of coking coal were also down in 1980 to 6.3 million t from 6.9 million t in 1979. Imports for general industry and other uses made up the remainder of Canada's foreign coal purchases. Coke imports grew in 1980 to 626 000 t, up from 520 000 t in 1979.

THERMAL POWER INDUSTRY

1980 was a record year for thermal coal consumption in Canada, with final utilization reaching 27.7 million t, up from 24.9 million t in 1979. Ontario was the largest consumer of thermal coal burning 10.7 million t or 39 per cent of the thermal coal consumed in Canada in 1980. Alberta consumed 38 per cent or 10.4 million t, Saskatchewan 5.0 million t or 18 per cent; Nova Scotia, 1.0 million t or 4 per cent; New Brunswick 314 000 t or 1 per cent; and Manitoba, 240 000 t or just under 1 per cent.

Of the 10.7 million t of thermal coal consumed by Ontario Hydro, nearly 8.4 million t or 80 per cent consisted of United States bituminous coal and about 20 per cent or 2.3 million t western Canadian bituminous coal. Consumption of western Canadian thermal coal will increase in Ontario throughout the early 1980s as the new Thunder Bay Generating Station begins operation in 1981, fueled with Saskatchewan lignite coal. Work is also under way on a coal-fired generating station at Atikokan in northwestern Ontario. This one-unit 206 MW station is currently slated to begin operation in 1984.

In 1980 thermal coal utilization in Alberta reached 10.4 million t, almost all sub-bituminous coal. By 1990 thermal coal consumption is forecast to double as over 2,500 MW of new coal-fired generating capacity is scheduled to come on-stream. During 1980, a new 375 MW coal-fired extension became operational at the Sundance Generation Station of Calgary Power Ltd. A


PRINCIPAL COAL MINES in CANADA, 1980

Alaska (U.S.A.)
Y.T.
NW.T.
B.C.
Alta
Sask.
Man.
Ont.
Que.
Nfld.
N.B.
P.E.I.
N.S.
U.S.A.
1
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12
13
14
LEGEND
● PRODUCING MINES

similar size addition is scheduled for Alberta Power Limited's Battle River Station in 1981. Several new coal-fired stations are already approved for the 1980s. Two new 400 MW units will be constructed at Keephills, west of Edmonton and will become operational in 1983 and 1984. Two 375 MW units are planned for 1985 and 1986 at Sheerness northeast of Calgary. Similar sized units are under consideration at the proposed Genesee site southeast of Edmonton for 1987-88. By 1990, with this new capacity on-stream, Alberta will be Canada's leading thermal coal-consuming province.

TABLE 3. PRINCIPAL COAL PRODUCERS IN 1980

Company and Mine Location (Numbers refer to locations on map, page 5)	1980 Raw Coal Production (000 tonnes)	Coal Rank	Chief Markets	Remarks
Nova Scotia				
1. Cape Breton Development Corporation (DEVCO)				
Lingan Mine, Lingan	1 690	Hvb A	Power generation	Underground
No. 26, Glace Bay Colliery	999	Hvb A	Metallurgical, Industrial, Domestic	Underground
Prince Mine, Point Aconi	219	Hvb A	Power generation	Underground
Novaco, Point Aconi	55	Hvb A	Power generation	Surface
Thomas Brogan Limited Florence	69		Power generation Residential	Surface
2. Evans Coal Mines Limited St. Rose	41	Hvb B	Power generation Residential	Underground
3. Thorburn Mining Limited Stellarton	44		Power generation Residential	Underground
New Brunswick				
4. N.B. Coal Limited Minto, Chipman areas	439	Hvb A	Power generation Paper mills	Surface
Saskatchewan				
5. Manitoba and Saskatchewan Coal Company (Limited) M&S Mine, Bienfait	537	Lig A	Power generation Industrial	Surface
5. Boundary Dam Mine, Estevan	1 689	Lig A	Power generation	Surface
5. Manalta Coal Ltd. Klimax Mine, Estevan	714	Lig A	Power generation Industrial	Surface
5. Manalta Coal Ltd. Utility Mine, Estevan	2 440	Lig A	Power generation	Surface
5. Saskatchewan Power Corporation Souris Valley Coal Mine, Estevan	304	Lig A	Power generation	Surface
6. Saskatchewan Power Corporation Poplar River Mine, Coronach	285	Lig	Power generation	Surface

TABLE 3 (cont'd)

Company and Mine Location	1980 Raw Coal Production (000 tonnes)	Coal Rank	Chief Markets	Remarks
Alberta				
Sub-bituminous Mines				
7. Manalta Coal Ltd. Roselyn Mine, Sheerness	76	Sub C	Power generation	Surface
8. Manalta Coal Ltd. Vesta Mine, Halkirk	925	Sub C	Power generation Residential	Surface
8. Forestburg Collieries Limited Diplomat Mine, Forestburg	815	Sub C	Power generation Residential	Surface
9. Manalta Coal Ltd. Whitewood Mine, Wabamun	2 195	Sub A & B	Power generation	Surface
Highvale Mine, Sundance	6 469	Sub C	Power generation	Surface
Bituminous Mines				
10. Coleman Collieries Limited Tent Mountain, Coleman	865		Japan for coke-making	Surface
11. Cardinal River Coals Ltd. Cardinal River Mine	2 942	Mvb	Japan for coke-making	Surface
11. Luscar Sterco Ltd. Coal Valley Mine	4 256	Mvb	Ontario Hydro and West Germany	Surface mine opened in 1978
12. McIntyre Mines Limited Smoky River Mines, Grand Cache	1 082 1 325	Lvb	Japan for coke-making	Surface and underground
British Columbia				
13. Kaiser Resources Ltd. Michel Colliery, Natal Harmer Ridge, Sparwood	703 5 966	Lvb	Japan for coke-making	Surface and underground (hydraulic mining)
13. Fording Coal Limited Fording Mine, Fording Valley	5 573	Lvb	Japan for coke-making	Surface
13. Byron Creek Collieries Limited, Corbin Coal Mountain	1 062	Mvb	Ontario and Europe for steam generating	Surface
Yukon				
14. Cyprus Anvil Mining Corporation, Carmacks Coal Mine, Carmacks	18	Hvb B	Anvil lead-zinc mine for heating and concentrate drying	Underground

Sources: Statistics Canada; Energy, Mines and Resources Canada.

Note: An - Semi-anthracite; Lvb - Low volatile bituminous ; Mvb - Medium volatile bituminous; Sub - Sub-bituminous; Lig - Lignite; Hvb - High volatile bituminous.

In Saskatchewan, thermal coal consumption in 1980 was the same as in 1979, 4.9 million t but by 1981 consumption will increase to over 6 million t. In January 1981 the first of two 300 MW units at Poplar River began commercial operation, with the second 300 MW unit scheduled to be operational by October 1982. Feasibility studies for two new coal-fired generating facilities that would use southern Saskatchewan lignite coal were announced by the Saskatchewan Power Corporation (SPC) in mid-1980. Tentative start-up date would be in the late 1980s and the size of the new facilities about 300 MWs.

Thermal coal consumption in New Brunswick was 314 000 t in 1980, up considerably from 198 000 t in 1979. The 200 MW dual coal-oil-fired Dalhousie II Generating Station was put in operation in 1980 and by 1981 will double the provincial generation of electricity from coal. The Dalhousie unit can burn up to .5 million t of coal annually if operated at full capacity on coal. A new coal mine in the Salmon Harbour area is under development by The New Brunswick Coal Company to supply up to 300 000 t of coal annually for this facility.

Thermal coal consumption in Nova Scotia in 1980 was 1.0 million t, up over 60 per cent from 644 000 t consumed in 1979. Lingan II, the second of two new 150 MW coal-fired units, began commercial operation in June 1980. Nova Scotia now has over 600 MW of coal-fired capacity and this could more than double by the end of this decade.

PRODUCTION OF MAJOR MINES

Coal production in British Columbia was divided between three major producers in 1980; Kaiser Resources Ltd., Fording Coal Limited and Byron Creek Collieries Limited (Table 3). In October 1980 the British Columbia Resources Investment Corporation acquired Kaiser Resources Ltd. and in January 1981 changed the name to B.C. Coal Ltd. Raw coal production in 1980 fell to 6.0 million t, down from over 8 million t in 1979, primarily because of a strike at the Sparwood operations. Production at the nearby Fording operation was up slightly to 5.6 million t, while output at Byron Creek Collieries for the first time exceeded one million t of raw coal. The majority of the output from Kaiser Resources Ltd. and

TABLE 4. PRODUCER'S DISPOSITION OF CANADIAN COAL[1], 1980

	Originating Province					
Destination	Nova Scotia	New Brunswick	Saskatchewan	Alberta	British Columbia	Canada
			(000 tonnes)			
Railways in Canada	-	-	52	-	-	52
Newfoundland	2	-	-	-	-	2
Prince Edward Island	11	-	-	-	-	11
Nova Scotia	1 955	1	-	120	-	2 076
New Brunswick	59	419	-	-	-	478
Quebec	36	19	-	-	-	55
Ontario	99	-	84	1 630	551	2 364
Manitoba	-	-	383	8	59	450
Saskatchewan	-	-	5 449	103	-	5 552
Alberta	-	-	-	10 679	-	10 679
British Columbia	-	-	-	6	184	190
Total Canada	2 162	439	5 968	12 546	794	21 909
United States	-	-	-	-	-	-
Japan	-	-	-	3 396	7 724	11 120
Others	547	-	-	1 198	2 399	4 144
Total shipments	2 709	439	5 968	17 140	10 917	37 173

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Saleable coal (raw coal, clean coal and middling sales); - Nil.

TABLE 5. SUMMARY OF COAL SUPPLY-DEMAND, 1970-80

	CANADA PRODUCTION				IMPORTS				
Year	Bituminous	Sub-Bituminous	Lignite	Total	Anthracite	Bituminous	Total Available	Domestic Consumption	Exports
			(million tonnes)						
1970	8.1	3.5	3.4	15.0	0.4	17.2	32.6	25.7	4.0
1971	9.7	4.0	3.0	16.7	0.4	15.7	32.8	25.3	7.0
1972	11.3	4.4	3.0	18.7	0.4	16.4	35.5	24.2	8.5
1973	12.3	4.5	3.6	20.4	0.4	14.6	35.4	25.0	10.3
1974	12.5	5.1	3.5	21.1	0.4	12.0	33.5	24.9	10.5
1975	15.8	6.0	3.5	25.3	0.4	15.4	41.1	25.5	11.4
1976	14.4	6.4	4.7	25.5	0.3	14.3	40.1	28.2	11.9
1977	15.3	7.9	5.5	28.7	0.4	15.0	44.1	30.8	12.4
1978	17.1	8.3	5.1	30.5	0.3	13.8	44.6	31.7	14.0
1979	18.4	9.6	5.0	33.0	0.2	17.3	50.5	34.8	13.7
1980	20.2	10.5	6.0	36.7	0.3	15.5	52.5	37.3	15.3

Sources: Statistics Canada; Energy, Mines and Resources Canada.

TABLE 6. CANADA, COAL PRODUCTION, IMPORTS, EXPORTS AND CONSUMPTION, 1976-80

	Production	Imports	Exports	Domestic Consumption
	(000 tonnes)			
1976	25 475	14 622	11 857	28 220
1977	28 681	15 439	12 387	30 896
1978	30 477	14 119	14 000	31 738
1979	33 013	17 524	13 698	34 764
1980	36 664	15 829	15 269	37 333

Sources: Statistics Canada; Energy, Mines and Resources Canada.

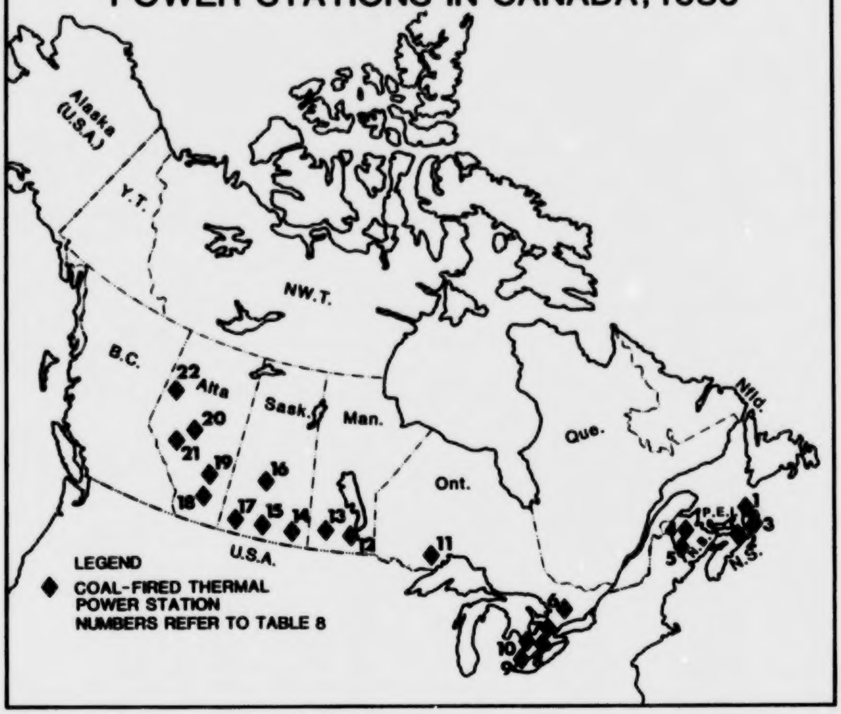
Fording Coal Limited was exported to Asian and other coking coal markets, while Byron Creek marketed the majority of its output to Ontario for use in the generation of electricity. Major expansions are under way at both the Kaiser and Fording operations.

Raw coal production was up in Alberta for both bituminous and sub-bituminous coals. Production at each of the Highvale, Whitewood and Vesta mines, operated by Manalta Coal Ltd. was up, while output at the Roselyn Mine decreased in 1980 due to a strike. Output of sub-bituminous coal at Luscar Ltd.'s Diplomat Mine at Forestburg also increased in 1980. Production of bituminous coal from mines at Cardinal River, Coal Valley and Grande Cache

TABLE 7. SUMMARY OF COAL DEMAND, 1976-80

	1976	1977	1978	1979	1980
			(000 tonnes)		
DEMAND					
Thermal Electric					
Canadian Coal	11 755	13 870	13 931	16 104	19 314
Imported Coal	7 289	8 572	8 984	8 857	8 468
Total	19 044	22 442	22 915	24 961	27 782
Metallurgical					
Canadian Coal	719	938	1 195	1 272	961
Imported Coal	6 670	5 726	5 714	6 593	6 279
Total	7 389	6 664	6 909	7 865	7 240
General Industry					
Canadian Coal	609	691	766	963	1 190
Imported Coal	962	914	922	751	955
Total	1 571	1 605	1 688	1 714	2 145
Space Heating					
Canadian Coal	189	163	199	200	166
Imported Coal	27	22	27	24	-
Total	216	185	226	224	166
Exports					
Canadian Coal	11 857	12 387	14 000	13 698	15 269
Total					
Canadian Coal	25 129	28 049	30 091	32 237	36 900
Imported Coal	14 948	15 234	15 647	16 225	15 702
Total Coal Demand	40 077	43 283	45 738	48 462	52 602

Sources: Statistics Canada; Energy, Mines and Resources Canada.



PRINCIPAL COAL-FIRED THERMAL POWER STATIONS IN CANADA, 1980

Alaska (U.S.A.)
Y.T.
NW.T.
B.C.
Alta
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.S.
U.S.A.
1
3
5
6
9
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18
19
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21
22
LEGEND
◆ COAL-FIRED THERMAL POWER STATION
NUMBERS REFER TO TABLE 8

TABLE 8. PRINCIPAL COAL-FIRED THERMAL POWER STATIONS IN CANADA, 1980

Utilities (numbers refer to locations on map, page 11)	Station	Capacity (KW)	Coal Consumption (000 tonnes)	Remarks
Nova Scotia				
1. Nova Scotia Power Corporation	Seaboard	111 000	555 071	
2. Nova Scotia Power Corporation	Maccan	25 000	8 446	
2. Nova Scotia Power Corporation	Trenton	210 000	371 829	
3. Nova Scotia Power Corporation	Lingan	300 000	616 908	Two new 150-MW units to come on-stream in 1984 and 1985.
New Brunswick				
4. New Brunswick Electric Power Commission	Dalhousie	200 000	105 120	
5. New Brunswick Electric Power Commission	Grand Lake No. 1	13 750	209 433	
	Grand Lake No. 2	85 000	105 120	
Ontario				
6. Ontario Hydro	Richard L. Hearn	1 222 500	403 405	
7. Ontario Hydro	Lakeview	2 422 500	1 937 296	
8. Ontario Hydro	Nanticoke	4 022 500	4 822 148	
9. Ontario Hydro	J. Clark Keith	271 500	22 902	Mothballed.
10. Ontario Hydro	Lambton	2 022 500	3 396 336	
11. Ontario Hydro	Thunder Bay	128 300	197 224	Two new 149-MW units to come on-stream in 1981.
Manitoba				
12. Manitoba Hydro	Selkirk	155 800	73 646	
13. Manitoba Hydro	Brandon	237 000	166 674	
Saskatchewan				
14. Saskatchewan Power Corporation	Estevan	70 000	442 721	
15. Saskatchewan Power Corporation	Boundary Dam	875 000	4 398 581	
16. Saskatchewan Power Corporation	Queen Elizabeth	232 000	106 829	
17. Saskatchewan Power Corporation	Poplar River	300 000	23 605	One new 300-MW unit to come on-stream in 1982.
Alberta				
18. Alberta Power Limited	Drumheller	15 000	1 583 301	
19. Alberta Power Limited	Battle River	362 000		One 375-MW unit to come on-stream in 1981.
20. Calgary Power Ltd.	Wabamun	582 000	1 878 782	
21. Calgary Power Ltd.	Sundance	2 100 000	6 456 135	
22. Alberta Power Limited	H.R. Milner	150 000	505 234	

Source: Energy, Mines and Resources Canada.

increased in 1980, while output at Coleman declined because of the closing of its Vicary Creek underground operation.

Overall production of lignite coal at Saskatchewan's five existing mines increased in 1980. One new mine, the Poplar River Mine owned by Saskatchewan Power Corporation located in the southwestern corner of the province came on-stream in 1980. This mine was developed to fuel the first of two new 300 MW units at the Poplar River Generating Station. The first unit of this station was put in operation in 1980 and the second is scheduled to be operational in 1982.

Coal production in eastern Canada increased in both New Brunswick and Nova Scotia in response to greater use of coal for the generation of electricity. Production in New Brunswick grew to 439 000 t, up from 310 000 t in 1979. Production is expected to peak in New Brunswick at approximately 600 000 t annually in the early 1980s.

Raw coal production reached a modern day record level of 3 million t in Nova Scotia as output increased at the three major mines owned by the Cape Breton Development Corporation (DEVCO). The majority of this increased output was consumed in the two new 150 MW thermal power units at Lingan near Sydney. The second unit became operational in 1980 and third and fourth units are scheduled to be in operation in 1984 and 1985. In addition, a new mine controlled by the provincial Crown corporation Novaco, became operational at Point Aconi in 1980. This strip mine will produce approximately 200 000 t annually for the next few years.

COKE INDUSTRY

In 1980 Canadian coke production was 5.2 million t, down 10 per cent from the 5.7 million t produced in 1979. Just over 7.2 million t of bituminous coking coal was used in the production of this coke, 87 per cent of which was imported from the United States. The remaining 13 per cent was Canadian coking coal, the majority produced and utilized in Sydney, Nova Scotia.

TABLE 9. COAL USED BY THERMAL POWER STATIONS IN CANADA, BY PROVINCES, 1963-80

	Nova Scotia	New Brunswick	Ontario	Manitoba	Saskat-chewan	Alberta	Total Canada
				(000 tonnes)			
1963	484	97	2 547	60	956	528	4 672
1964	530	222	2 795	132	1 006	999	5 684
1965	633	334	3 567	175	1 085	1 211	7 005
1966	799	294	3 500	79	1 116	1 360	7 148
1967	758	275	4 435	38	1 334	1 427	8 267
1968	646	240	5 523	179	1 354	2 128	10 070
1969	676	150	6 424	51	1 123	2 378	10 802
1970	548	113	7 696	503	1 969	2 951	13 780
1971	689	271	8 560	446	1 996	3 653	15 615
1972	663	281	7 599	410	2 145	4 113	15 211
1973	585	193	6 615	386	2 806	4 474	15 059
1974	606	292	6 721	132	2 902	4 771	15 424
1975	571	248	6 834	323	3 251	5 345	16 572
1976	730	207	7 612	979	3 521	5 996	19 045
1977	572	198	8 795	1 113	4 304	7 461	22 443
1978	711	151	9 097	341	4 585	8 029	22 914
1979	644	198	9 901	73	4 956	9 181	24 956
1980	1 052	315	10 779	240	4 972	10 424	27 782

Sources: Statistics Canada; Energy, Mines and Resources Canada.

The Algoma Steel Corporation, Limited of Sault Ste. Marie, Ontario, produced 1.4 million t of coke from 1.9 million t of coking coal. In 1980 the company announced plans for the construction of a new $120 million coke oven battery.

Stelco Inc. produced 2.0 million t of coke at its Hamilton, Ontario, facilities in 1980 with 3.3 million t of coking coal. On June 1, 1980, Stelco began production of steel at its new Nanticoke site at Lake Erie. Construction at this facility is ongoing, and work on the coke ovens and hot strip mill will be complete in 1981 and 1983 respectively.

Dofasco Inc. of Hamilton, Ontario, produced 1.2 million t of coke in 1980 from 1.5 million t of coking coal. While Dofasco and Stelco both used some Canadian coal, the majority of the coking coal used by Ontario steel companies was imported from the United States.

Sydney Steel Corporation (Sysco) of Sydney, Nova Scotia, produced 470 000 t of coke from 675 000 t of coking coal. Unlike the Ontario steel producers, Sysco used mostly Canadian coal to produce its coke. During 1980, representatives of Sysco, the Nova Scotia government and the federal Department of Regional and Economic Expansion (DREE), studied a multi-million dollar ten-year renovation program for Sysco.

In 1980 Kaiser Resources Ltd. produced 95 000 t of coke at its facilities near Natal, British Columbia. Coking coal input was 129 000 t, all of which came from nearby coal mines.

CANADA'S COAL TERMINALS

There were four major coal terminals in operation in Canada during 1980. Exports from Canada's west coast are currently handled by three terminals: Pacific Coast Terminals Co. Ltd., Westshore Terminals Ltd. and Neptune Bulk Terminals Ltd. These facilities located in or near Vancouver presently handle over 14 million t of coal exports annually. Existing terminal capacity in British Columbia is being expanded to handle the increased exports forecast for the 1980s. Construction on one and preparations for a second new terminal, widening of the existing causeway and expansion of storage capacity will initially double and could ultimately nearly triple the throughput capacity of Westshore Terminals Ltd. at Roberts Bank to approximately 27 million t annually.

TABLE 10. EXPORT DEMAND FOR CANADIAN COAL 1979 AND 1980

Country	1979		1980	
	(000 t)	($000)[1]	(000 t)	($000)[1]
Japan	10 485	618,753	11 123	686,844
United States	41	761	1	15
Denmark	133	4,832	252	9,526
Chile	49	2,886	159	9,541
France	72	3,317	-	-
Korea	852	49,920	1 296	79,217
Germany	641	22,799	603	27,708
Sweden	164	8,358	192	10,141
Mexico	60	3,419	28	1,793
Pakistan	-	-	25	1,536
Belgium	56	2,755	21	1,397
Brazil	423	25,343	633	40,414
Argentina	27	1,784	45	3,099
Italy	132	7,679	48	3,015
Taiwan	57	3,356	216	13,193
Spain	154	9,348	48	2,921
Greece	55	2,669	316	16,809
India	297	17,136	263	16,098
Total	13 698	785,115	15 269	923,267

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] fob port of export Canada dollars.

- Nil.

Plans are also being made to construct a major coal terminal at Prince Rupert, British Columbia, with initial capacity of about 12 million tpy. This facility will be capable of handling up to 250 000 dwt (deadweight ton) vessels.

A large coal terminal is also located at Thunder Bay, Ontario. It currently transships western Canadian coal to thermal generating stations in Ontario. This installation became operational in 1978 and, while it now handles nearly 3 million tpy, throughput capacity is in excess of 6 million t annually.

On the east coast the only major coal terminal is owned by the Cape Breton Development Corporation at Sydney, Nova Scotia. This coal port has at present a throughput capacity of about 1.5 million tpy. In 1980 studies were initiated to investigate the possible expansion of the existing pier facilities to provide for a new shiploader, new docking facilities and new shiptrimmer which in combination with a new railroad control system and new automatic sampling equipment could significantly increase the capacity of this port.

TABLE 11. COKE OVEN AND OTHER CARBONIZATION PLANTS IN CANADA, 1980

Company	Operating Batteries and No. of Ovens	Oven Type	Year Built	1980 Coal Feed	1980 Coke Production	Byproduct
				(000 tonnes/year)		
The Algoma Steel Corporation, Limited Sault Ste. Marie, Ontario	No. 5-86	Koppers-Becker	1943	2 062	1 440	Tars, light oil, gas
	No. 6-57	Koppers-Becker	1953			
	No. 7-57	Wilputte Underjet	1958			
	No. 8-60	Wilputte Underjet	1967			
	No. 9-60	Wilputte Underjet	1978			
Stelco Inc. Hamilton, Ontario	No. 3-61	Wilputte Underjet	1947	3 318	2 055	Tars, gas, light oil, anhydrous ammonia
	No. 4-83	Wilputte Underjet	1952			
	No. 5-47	Wilputte Underjet	1953			
	No. 6-73	Otto Underjet	1967			
	No. 7-83	Otto Underjet	1972			
Stelco Inc. Nanticoke, Ontario	No. 1-45	Otto Underjet	Complete for production in 1981			
Dofasco Inc. Hamilton, Ontario	No. 1-25	Koppers-Becker Gun Type Comb.	1951	1 510	1 190	Tars, light oil, gas sulphur, ammonium, sulphate
	No. 2-35	Koppers-Becker Gun Type Comb.	1956			
	No. 3-45	Koppers-Becker Gun Type Comb.	1958			
	No. 4-53	Koppers-Becker Gun Type Comb.	1967			
	No. 5-53	Koppers-Becker Gun Type Comb.	1971			
	No. 6-35	Koppers-Becker Gun Type Comb.	1978			
Sydney Steel Corporation Sydney, Nova Scotia	No. 6-6	Koppers-Becker Underjet	1949	679	470	Tars, light oil, gas
	No. 6-61	Koppers-Becker Underjet	1953			
Kaiser Resources Ltd. Natal, British Columbia	16 Units	Curran-Knowles	1949	128	95	Crude tar, gas, coke breeze
	16 Units	Curran-Knowles	1952			
Manitoba and Saskatchewan Coal Company (Limited) Char Briquetting Div. Bienfait, Saskatchewan	2 Units	Lurgi Carbonizing Retort	1925			
	1 Unit	Lurgi Carbonizing Retort				
	3 Units	Salem Rotary Hearth Calciners	1974			

Source: Energy, Mines and Resources Canada.

TABLE 12. CANADA, COKE PRODUCTION AND TRADE, 1970-80

	Production		Imports		Exports	
	Coal Coke	Petroleum Coke	Coal Coke	Petroleum Coke	Coal Coke	Petroleum Coke
			(tonnes)			
1970	5 142 122	188 376	358 295	706 769	248 469	48 313
1971	4 631 897	187 278	586 430	665 774	288 272	11 171
1972	4 675 866	242 370	481 816	555 710	238 478	881
1973	5 369 861	286 530	357 815	637 664	367 916	1 960
1974	5 443 427	274 412	509 058	746 033	260 892	24 940
1975	5 277 837	270 685	546 456	572 557	96 081	161 576
1976	5 289 185	678 432	287 249	591 859	169 895	136 970
1977	4 845 066	921 363	382 827	986 678	198 727	157 191
1978	4 967 664	1 014 076	482 842	973 985	217 595	134 762
1979	5 775 141	1 105 433	520 534	980 657	228 601	125 416
1980	5 249 744	1 156 444	626 923	908 322	319 554	150 200

Source: Energy, Mines and Resources Canada.

Cobalt

D.G. FONG

INTRODUCTION

Canadian cobalt production increased by 15 per cent to 1 590 tonnes (t) in 1980. Two of the three Canadian companies which produced cobalt registered marked output increases as a result of growing receipts of ore for custom treatment. Production from the third company increased marginally, however, partly because of a strike in one segment of the operation, and partly due to a production cutback during the last quarter of 1980.

The demand for cobalt in 1980 softened considerably in response to a continuing high price and the depressed economic performance of many countries. Because of the high price, substitutes have made significant inroads into the cobalt market, particularly in the permanent magnet and hard facing areas. Consumption of superalloys remained strong, especially during the early part of the year. Substitution was a less serious problem in catalytic production than in other applications.

Producer inventories of cobalt, almost nonexistent in January, began to accumulate at the beginning of the summer. By year-end, Zaire and Zambia, the world's two leading producers, were carrying large cobalt stocks. The merchant market price weakened considerably as a result, although the producer price was maintained at $US 25 a pound throughout 1980. The outlook for the cobalt market is not expected to improve significantly unless there is some offsetting demand such as the building of strategic and economic stockpiles in western economies.

CANADA AND OFF-SHORE OPERATIONS OF CANADIAN PRODUCERS

Canadian cobalt production increased by 15 per cent from 1 381 t in 1979 to 1 590 t in 1980. Two companies, Inco Limited and Falconbridge Nickel Mines Limited, recovered cobalt as a byproduct from nickel-copper production, while a third, Sherritt Gordon Mines Limited, recovered cobalt from domestic and imported nickel refinery feed. Much of the product refined by Sherritt was processed on a toll basis.

Currently, Inco is producing commercial grade cobalt oxide at Port Colborne, Ontario and Thompson, Manitoba. This product is shipped to Inco's refinery at Clydach, Wales, where refined cobalt oxides and salts are produced. The Clydach refinery, which suffered both a strike and the effect of a severe flood in late 1979, was back to full operation two months after its workers returned on March 3, 1980.

Inco is building a $25 million electro-cobalt plant at its Port Colborne nickel refinery. Start-up is scheduled for the end of 1982 or early 1983 at a capacity of 907 tpy of cobalt metal. An existing cobalt recovery circuit at Port Colborne will provide refinery feed for the plant. The electro-cobalt product from the new facility will replace current cobalt oxide production. However, cobalt oxide will continue to be produced at the Thompson refinery.

At Kristiansand, Norway, Falconbridge's nickel refinery recovers electrolytic cobalt from nickel-copper matte produced in

TABLE 1. CANADA, COBALT PRODUCTION TRADE AND CONSUMPTION, 1979 AND 1980

	1979		1980P	
	(kilograms)	($)	(kilograms)	($)
Production[1] (all forms)				
Ontario	1 277 940	86,299,973	1 216 000	70,110,000
Manitoba	361 684	23,044,167	387 000	24,909,000
Total	1 639 624	109,344,140	1 603 000	95,019,000
Exports				
Cobalt metal				
United States	259 914	18,252,000	227 696	13,750,000
Netherlands	1 814	116,000	64 135	3,375,000
West Germany	9 546	331,000	14 346	1,521,000
South Africa	10 565	1,801,000	9 036	987,000
Mexico	30	3,000	5 443	353,000
Other countries	14 277	1,154,000	4 251	305,000
Total	296 146	21,657,000	324 907	20,291,000
Cobalt oxides and hydroxides[2]				
United Kingdom	427 900	7,554,000	1 066 000	40,384,000
Norway	-	-	25 000	1,195,000
Belgium and Luxembourg	17 200	800,000	-	-
Total	445 100	8,354,000	1 091 000	41,579,000
Consumption[3]				
Cobalt contained in:				
Cobalt metal	86 422		80 981	
Cobalt oxide	19 053		14 766	
Cobalt salts	9 131		9 478	
Total	114 606	..	105 225	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Production (cobalt content) from domestic ores. [2] Gross weight. [3] Available data reported by consumers.
P Preliminary; - Nil; .. Not available.

TABLE 2. CANADA, COBALT PRODUCTION, TRADE AND CONSUMPTION, 1970 AND 1975-80

		Exports		Imports		
	Production[1]	Cobalt metal	Cobalt oxides and hydroxides	Cobalt ores[2]	Cobalt oxides and hydroxides[3]	Consumption[4]
			(tonnes)			
1970	2 069	381	837	..	..	148
1975	1 354	431	561	..	..	123
1976	1 356	523	471	-	96	160
1977	1 485	684	605	519	68	147
1978	1 233	716	748	85	83	145
1979	1 640	296	445	190	46	115
1980P	1 603	325	1 091	W	26	105

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Production from domestic ores, cobalt content. Production includes cobalt content of Inco Limited and of Falconbridge Nickel Mines Ltd. shipments to overseas refineries. [2] Cobalt content. [3] Gross weight. [4] Consumption of cobalt in metal, oxides and salts.
P Preliminary; - Nil; .. Not available; W Withheld to avoid disclosing confidential company data.

Canada. Refined cobalt production increased appreciably in 1980 to 806 t from 681 t in 1979; however, much of the production surge resulted from an increase in toll refining.

Sherritt Gordon refined cobalt and nickel at its Fort Saskatchewan, Alberta facility from concentrates produced by other companies. The expansion of the refinery was completed in 1980, and production of cobalt during the year was 692 t, an increase of 14 per cent over 1979. The company is continuing to increase its cobalt refining capacity and by 1981 the plant will be capable of producing cobalt metal powder at a rate of 820 tpy.

Three mining companies in Canada, Agnico-Eagle Mines Limited, Teck Corporation and Canadaka Mines Limited, produced cobalt-bearing silver concentrates in the Cobalt area of Ontario. Concentrates from Agnico-Eagle and Canadaka were treated at the nearby silver refinery of Canadian Smelting & Refining (1974) Limited (CSR) while flotation concentrates from Teck were being shipped abroad for processing. Cobalt is not being recovered currently at the CSR plant. Precipitates and residues containing about 9 per cent cobalt were stockpiled with the intention of recovering the cobalt at some future date by installing a cobalt recovery circuit, or until a market can be found for their sale.

WORLD REVIEW

The demand for cobalt weakened considerably in 1980 and merchant market prices declined. On the other hand, the producer price of cobalt remained unchanged at $US 25 a pound. Recent high prices and an anticipated price decline have resulted in a significant reduction of consumer stocks and the building of producer inventories. By year-end, Zaire and Zambia, the world's two leading producers, were carrying large cobalt stocks.

World cobalt production from primary sources in 1980 totaled about 28 700 t, about 4 per cent higher than in 1979. Production from secondary sources such as the recovery of cobalt from alloy scraps and spent catalysts was substantially higher. The 70 per cent allocation practice imposed by major U.S. cobalt dealers on May 1, 1978 and maintained throughout 1979, was lifted on July 3, 1980.

Some 60 per cent of the world's cobalt supply originated in Zaire and Zambia; both countries produced cobalt as a byproduct of copper mining. In 1980, Zaire produced 14 482 t of cobalt, more than one-half of the world's total output. The 1980 output was a substantial increase over 1979 production of 12 000 t, achieved despite the termination of cobalt recovery from stockpiled tailings. Zaire was continuing its expansion program; La Générale des Carrières et des Mines (GECAMINES), the state mining company, brought on-stream in 1980 the Dima concentrator, a 4.5 million tpy processing plant located in Kolwezi.

In Zambia, cobalt production in 1980 was 3 309 t which compares with 3 176 t in 1979. Both state-controlled companies, Roan Consolidated Mines Ltd. (RCM) and Nchanga Consolidated Copper Mines Ltd. (NCCM) have initiated expansion plans which could double Zambia's capacity to about 7 000 t by 1985. RCM planned to add 360 tpy of cobalt production capacity to raise the Chambishi refinery capacity to 2 720 tpy of cobalt metal. The company also obtained a loan valued at $US 11 million from the European Investment Bank to cover part of the cost of installing a vacuum refining plant at the company's Chambishi refinery. The new facility, expected to be completed by the end of 1981, will produce a higher grade of industrial cobalt and reduce metal losses. NCCM, with a current annual production capacity of 1 300 typ, expects to have an additional 2 600 t of capacity when its extraction plant as Rokana is completed in 1983.

Both Zaire and Zambia had been airlifting cobalt to markets following the Shaba invasion. The soft market, however, forced both countries to revert back to land routes. With the Benguela railway, the main exit route for Zaire and Zambia minerals, still closed during 1980, shipments were made through longer routes, some via the southern route through South African ports and some via the Tanzania route through the port of Dar Es Salaam.

In the Republic of South Africa, platinum mines were paying more attention to cobalt separation and recovery. Impala Platinum Limited planned to build a $US 15.9 million cobalt recovery plant at its nickel-copper refinery near Spring. The new plant, expected to be in operation by 1982, could produce at least 160 tpy of cobalt. At the end of 1980 Rustenburg Platinum Mines

TABLE 3. PRODUCER SHIPMENTS OF COBALT BY MAJOR CANADIAN PRODUCERS 1978-80

	1978	1979	1980
		(tonnes)	
Inco	771	562	885
Falconbridge	569	681	629
Sherritt Gordon	626	264	196
Total	1 966	1 507	1 710

Source: Company annual reports.

Ltd. completed a new nickel refinery which, when in full production, will double the company's production capacity of cobalt sulphate to 7 000 tpy.

Falconbridge was negotiating with the Government of Uganda for the reopening of the Kilembe copper-cobalt mine in Uganda. If an agreement can be reached, the company will prepare two feasibility studies - one relating to recovering and marketing cobalt concentrate which is now stockpiled in tailings, and the other to restart production at the Kilembe mine. The mine and tailings, located about 378 km from the Uganda capital, Kampala, were formerly operated by Falconbridge's affiliate, Kilembe Copper Cobalt Ltd., until they were nationalized by the previous government in 1975. The tailings were reported to have an average grade of 1.4 per cent Co and to contain 12 700 t of cobalt.

In the United States, Noranda Mines Limited was redeveloping the Blackbird mine, which has not produced cobalt since 1960. This mine, located near Salmon, Idaho, could be in operation by 1984 with an annual production capacity of 2 000 t of cobalt contained in concentrate. Average mineable reserves in 1980 were 2.3 million t grading 0.61 per cent cobalt and 1.2 per cent copper. The company has completed the rehabilitation of a 270 tpy mill and a metallurgical pilot plant is already in operation. Noranda was evaluating the feasibility of constructing a cobalt refinery to treat the Blackbird mine concentrate. Other cobalt properties in the United States that could be brought into production include the Madison mine near Fredericktown, Missouri, and the Gasquet Mountain cobalt-chromium-nickel deposit in northwestern California.

Also in the United States, Carolmet, Inc., a subsidiary of Metallurgie Hoboken-Overpelt began production of extra-fine cobalt powder in June 1980 at its Laurinsburg, North Carolina plant. The new plant, using cobalt from Zairian sources, should be able to supply the U.S. market with 500 tpy of cobalt powder.

Currently no cobalt is being mined in the United States. To ensure an adequate supply in case of emergency, the General Services Administration (GSA) has been carrying cobalt as part of the strategic commodity stockpiles. The 1980 GSA stockpile of cobalt was 18 500 t, whereas the new national stockpile goal has been set at 38 700 t. Toward the year-end, there were strong indications that GSA will in the near future acquire more cobalt to fulfill its stockpile goal. The resumption of cobalt mine production in the United States would reduce its dependence on cobalt from outside sources and could result in lower stockpile goals.

CONSUMPTION AND USES

With the continuing high price of cobalt and consumers' determined efforts to reduce reliance on imported commodities, world cobalt consumption during 1980 fell by 25 per cent to about 18 000 t. Apart from the effect of economic recession; substitution, recycling, redesign of products and the development of new materials were the major factors in the reduction of cobalt consumption. An application that was affected the most was the permanent magnet sector where cobalt has been an important component, especially in the aluminum-nickel-cobalt (Alnico) magnets. It was estimated that up to 40 per cent of this market for cobalt has been lost since 1978. Alternative materials range from ceramic-ferrite which contains no cobalt to rare earth-cobalt magnets that use only one-third to one-half of the amount of cobalt required for Alnico magnets. The rare-earth magnets also have a weight-reduction advantage, especially in applications where weight and size limitations are critical.

Cobalt is used in superalloys because it provides high strength, and wear and corrosion resistance at elevated temperatures. The major use of cobalt-base superalloys was in turbine blades for jet engines and power generation units, military equipment, and high-stress structural components such as engine mounts and landing gears. Cobalt-

TABLE 4. WORLD PRODUCTION OF RECOVERABLE COBALT, 1978-80

	1978	1979	1980
		(tonnes)	
Zaire[1]	13 125	14 100	14 482
Zambia[1]	2 062	3 176	3 309
Canada	1 233	1 380	1 590
Finland[1]	922	1 180	1 179
Morocco[1]	1 133	960	998
Philippines[1]	1 191	1 239	1 270
Australia[1]	1 360	1 542	1 596
Other Western	420	480	580
Subtotal	21 446	24 057	25 018
U.S.S.R.	1 950	1 810	2 040
Cuba	1 600	1 700	1 700
Total	24 996	27 567	28 758

[1] United States Bureau of Mines, Mineral Industry Surveys.

TABLE 5. WESTERN WORLD COBALT CONSUMPTION[e], 1980

Magnetic alloys	16%
Cemented carbides	7%
Superalloys and other alloys	47%
Ceramics and enamel	10%
Chemicals	20%
Total	100%

Source: **Engineering and Mining Journal.**
[e] Estimated.

base superalloys normally contain 20 to 65 per cent cobalt, while a small amount of cobalt is also contained in nickel- and iron-based superalloys. During 1980, the consumption of cobalt in superalloys continued strong, surpassing the 1979 level. The consumption growth of mine cobalt in this area will be partly restrained by the use of recycled superalloys, as a new process has been developed to refine superalloy scrap into usable superalloy. This scrap would otherwise be recycled into non-critical applications such as low-alloy or stainless steels.

As a chemical product, cobalt oxide is an important additive in paint, glass, and ceramics. Cobalt is also used to promote the adherence of enamel to steel for applications such as appliances, and steel to rubber for the construction of steel-belted tires. A cobalt-molybdenum-alumina compound is used as a catalyst in hydrogenation and in petroleum desulphurization. Although the consumption of cobalt as a catalyst has not been significantly affected by substitution, the cobalt content in other chemical applications has been substantially reduced.

Cobalt-base alloys are used in applications where difficult cutting is involved and high abrasion resistance qualities are required. The most important group of cobalt-base alloys is the stellite group containing cobalt, tungsten, chromium, and molybdenum as principal constituents. Hard-facing or coating of tools with cobalt alloys provides greater resistance to abrasion, heat, impact and corrosion. Cobalt metal powder is used as a binder in making cemented tungsten carbides for heavy-duty and high-speed cutting tools. While nickel-base alloys in recent years provided a ready substitute for cobalt alloys, the drop of cobalt consumption in the carbide industry during 1980 was more the result of recession than substitution.

PRICES

The producer price of cobalt was increased on February 1, 1979 to $US 25 per pound and remained at this quotation throughout 1979 and 1980. Dealer prices peaked at about $US 45 at the beginning of 1979, weakened to $US 17.50-19.50 in August 1980, and rebounded to $US 20-21.50 per pound in October 1980.

	Dec. 1979	Dec. 1980
	($US)	
Cobalt metal, per lb.		
fob New York		
Shot, 99.5%, 250-kg drum	25.00	25.00
Powder, 99%+		
300 and 400 mesh, 50-kg drums	31.09	27.92
extra fine, 125-kg drum	31.00	32.25

Source: **Engineering and Mining Journal,** January 1980 and 1981.

fob - free on board.

OUTLOOK

The outlook for cobalt in the long-term is for continuing growth in consumption but at a slower growth rate. In the near-term, the demand for cobalt in military and catalytic applications will continue to be firm. On the other hand, the demand for cobalt-base superalloy is expected to fall because of a decline in the manufacture of commercial aircraft engines. Substitution in the permanent magnet sector is likely to continue as long as cobalt prices remain high.

The world supply of cobalt will continue to increase in the next few years as new production capacity comes on-stream. This together with a continuing weak market will lead to a further inventory buildup unless there is an offsetting increase in demand. Demand would increase significantly if industrialized western countries such as the United States, West Germany, France and Japan decide to fulfill their strategic and economic stockpile goals.

TARIFFS

CANADA

Item No.		British Preferential	General Preferential	Most Favoured Nation	General
			(%)		
33200-1	Ore of cobalt	free	free	free	free
35103-1	Cobalt metal, excluding alloys, in lumps, powders, ingots or blocks	free	free	free	25
35110-1	Cobalt metal, in bars	free	free	9.6	25
92824-1	Cobalt hydroxides	10	8.5	13.1	25
	Temporary reduction June 3, 1980 to December 31, 1986	free	free		
92824-2	Cobalt oxides	free	free	10	20

MFN Reductions under GATT (effective January 1 of year given)

Item No.	1980	1981	1982	1983	1984	1985	1986	1987
				(%)				
35110-1	9.6	9.2	8.8	8.4	8.0	7.6	7.2	6.8
92824-1	13.1	11.3	9.4	7.5	5.6	3.8	1.9	free
92824-2	10	10	10	10	10	10	9.9	9.2

UNITED STATES

Item No.		
418.60	Cobalt oxide	1.2¢/lb
418.62	Cobalt sulphate	1.4%
601.18	Cobalt ore	free
632.20	Cobalt metal, unwrought waste and scrap	free

TARIFFS (cont'd)

		1980	1981	1982	1983	1984	1985	1986	1987
						(%)			
418.68	Cobalt compounds other than cobalt oxide and cobalt sulphate	5.8	5.6	5.3	5.1	4.9	4.7	4.4	4.2
426.24	Cobalt salts resinate	5.8	5.6	5.3	5.1	4.9	4.7	4.4	4.2
426.26	Cobalt salts, other	5.8	5.6	5.3	5.1	4.9	4.7	4.4	4.2
632.88	Cobalt metal alloys unwrought	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5
633.00	Cobalt metal wrought	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated 1980, USITC Publication 1011; U.S. Federal Register, Vol. 44, No. 241.

Columbium and Tantalum

D.G. FONG

OVERVIEW

In 1980, western world mine production was 20 800 tonnes (t) of contained columbium pentoxide (Cb_2O_5), an increase from 1979 of about 8 per cent. Canadian mine output, on the other hand, remained unchanged at 2 467 t Cb_2O_5. World consumption of columbium was estimated at over 20 000 t in 1980, an increase of about 10 per cent over 1979. The consumption of columbium superalloys for the aerospace industry continued to increase during 1980 while the demand for ferrocolumbium for steelmaking remained at about the same level as in 1979. The 1980 mine supply of columbium exceeded demand as a result of production increases at expanded Brazilian and Canadian mine operations. Shipments of mine concentrates from Brazil were terminated by the end of 1980 as the country continued its emphasis on the export of upgraded products. In addition to expanded ferrocolumbium production in 1980, Brazil also began large scale production of high-purity columbium oxide. The price of high-purity columbium oxide, which reached a record high in early 1980, dropped substantially toward year-end with increased availability of supply. Adequate worldwide supplies of both ferrocolumbium and high-purity oxide, coupled with stable prices, provide the basis for anticipating growth improvement in columbium usage.

Western world mine production of tantalum pentoxide (Ta_2O_5) in 1980 was 1 500 t, an increase of 7 per cent over 1979. Canadian tantalum production in 1980 was 140 t of contained Ta_2O_5, a 10 per cent decrease from the previous year. Western world tantalum consumption in 1980 was at about the same level as in 1979. Demand was particularly strong in early 1980 and this factor, in combination with a continuing tight supply, forced the tantalum price to a record high level. By mid-year, however, the upward trend in price was reversed as a result of the large increase in ore supply.

Capacitors and cemented carbides remained the two most important end-uses of tantalum, and together accounted for more than 70 per cent of the world's tantalum consumption. The remainder was consumed in various anticorrosion applications and alloys. Due to the high 1980 prices, tantalum capacitors continued to lose ground to aluminum and ceramic capacitor substitutes, particularly in low and medium-priced electronic devices. Tantalum coatings made some inroads in tool manufacture at the expense of tantalum carbides. However, there is a limited range of substitutability in these applications.

Columbium

CANADIAN PRODUCTION AND DEVELOPMENTS

Niobec Inc., Canada's only columbium producer, is located near Chicoutimi, Quebec. The company, a 50-50 joint venture between

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Quebec Mining Exploration Company (SOQUEM) and Teck Corporation, mines pyrochlore ore and has an annual capacity of 2 500 t of columbium pentoxide (Cb_2O_5) in concentrate. Production in 1980 was 2 467 t of Cb_2O_5, little changed from the 2 470 t of the previous year. Producers' shipments during 1980 totalled 2 330 t of Cb_2O_5 valued at $15 million, compared with 2 513 t and $15.3 million, respectively, in 1979. The mine product, a pyrochlore concentrate containing 60.4 per cent Cb_2O_5, was sold under long-term contracts to customers in Europe, Japan and the United States.

At a capital cost of $10 million, Niobec is expanding its annual production capacity by 30 per cent to 3 400 t of Cb_2O_5. The expansion program, expected to be completed in February, 1981 includes a deeper shaft and further underground development, along with additional surface facilities. The blending plant is being enlarged, and flotation cells and a second magnetic separator are being added in the mill.

St. Lawrence Columbium and Metals Corporation at Oka, Quebec had been a significant Canadian columbium producer until 1976. Early in 1976 operations ceased and subsequently, the firm was placed under receivership and much of its assets sold. While existing reserves are in the order of 25 million t averaging about 0.44 per cent columbium pentoxide, attempts to find new financing to re-establish the operation have been unsuccessful.

Masterloy Products Limited of Ottawa, Ontario has the capability of producing ferrocolumbium, but none was produced in 1980. This was attributable to potential environmental problems associated with the disposal of the radioactive contaminants present in most columbium concentrates.

WORLD PRODUCTION

In 1980, western world mine production of columbium was estimated at 20 800 t of contained pentoxide. Brazil, with two major producers, accounted for about 80 per cent of the world's production capacity. Companhia Brasileira Metalurgia e Mineracao S.A. (CBMM), by far the world's largest producer, was in the midst of a major expansion program. The company was constructing a new concentration plant at Araxa in the State of Minas Gerais. The new mill, scheduled for completion in mid-1981, will replace the existing plant and increase the

TABLE 1. CANADA, COLUMBIUM (NIOBIUM) AND TANTALUM PRODUCTION, TRADE AND CONSUMPTION, 1970 AND 1975-80

	Production[1]		Imports				Exports[2] Columbium Ores and Concentrates to U.S.	Consumption Ferrocolumbium and ferro-tantalum-Columbium, Cb and Ta-Cb Content
			Primary forms and fabricated metals					
	Cb_2O_5 Content	Ta_2O_5 Content	Columbium	Columbium Alloys	Tantalum	Tantalum Alloys		
					(kilograms)			
1970	2 129 271	143 800	..	..	..	..	576 227	132 449
1975	1 661 567	178 304	..	..	..	..	9 682	215 910
1976	1 498 634	139 833	1 767	-	2 619	655	542 604	189 602
1977	2 508 909	139 757	W	W	7 043	2 407	757 090	132 449
1978	2 473 045	158 776	1 705	-	7 655	1 535	552 657	163 293
1979	2 512 667	158 845	855	W	6 901	2 503	509 953	272 155
1980P	2 330 000	127 000	877	W	21 280	12 112	655 721	..

Sources: Energy, Mines and Resources Canada; Statistics Canada; U.S. Department of Commerce.

[1] Producers' shipments of columbium and tantalum ores and concentrates and primary products, Cb_2O_5 and Ta_2O_5 content. [2] From U.S. Department of Commerce, **Imports of Merchandise for Consumption, Report FT 135.** Quantities in gross weight of material.
P Preliminary; - Nil; .. Not available; W Withheld to avoid disclosing confidential company data.

output of Cb_2O_5 contained in concentrate from 14 500 tpy to 25 000 tpy. A second mill, to come on stream at the end of 1981, will double the output to 50 000 tpy.

CBMM's 1980 production of pyrochlore concentrate was estimated at 15 700 t, an increase of 2 070 t over 1979, while ferrocolumbium production in 1980 was about 15 370 t, up from 11 860 t in 1979. The other important Brazilian producer, Mineracao Catalao de Goias SA, had a production capacity in 1980 of 3 800 tpy of pyrochlore concentrate. In 1980, the company produced about 2 267 t of Cb_2O_5 in concentrates. Mineracao Catalao, part of the Brasimet Group, also operated a ferrocolumbium plant near Catalao, Brazil.

Brazilian exports of pyrochlore concentrates have been on the decline in recent years. Because the country is intensifying its efforts to export upgraded products rather than raw materials, an increasing portion of the concentrates produced is being committed for conversion into ferrocolumbium and high-purity columbium oxide. CBMM announced that the company would discontinue the export of concentrates as of December 31, 1980.

In countries other than Canada and Brazil, columbium is produced as a byproduct of tantalum-recovery operations. For example, columbite is recovered from tantalum ore in Nigeria, and from tantalum-bearing tin slags in Malaysia and Thailand. Historically, the columbite produced from these operations has been the only source of pure columbium oxide for making high-purity ferrocolumbium, alloys and metal. In 1980, however, CBMM began production of pure columbium oxide using pyrochlore as a raw material. Meanwhile, in the United States, Teledyne Wah Chang, Albany, of Albany, Oregon also began producing pure columbium oxide from pyrochlore for intracorporate use. CBMM and Teledyne each produced about 450 t of high-purity oxide in their first year of operation, and each has the capability to produce three or four times as much should world markets warrant.

USES

The steel industry is the largest consumer of columbium, which is used in the form of ferrocolumbium as an additive element in high strength low alloy (HSLA) steels, carbon steels, low-alloy steels, stainless steels and superalloys. The HSLA steel industry is the largest market for columbium. Although the quantity of the metal added to HSLA steel may be as low as 0.02 per cent, the mechanical properties and tensile strength of the steel are significantly improved. These characteristics are particularly important in applications such as pipeline steels, automotive components and structural steels where the strength-to-weight ratio is critical.

High-purity columbium oxide is used mainly in superalloys for manufacturing aircraft and turbine engines. A columbium addition to the cobalt and nickel-based superalloys improves the high-temperature characteristics of the alloys. In the manufacture of high-alloy and stainless steels, columbium is used to impart resistance to corrosion at elevated temperatures, a property of particular importance in coal gasification and sour natural-gas and smelter gas processing.

The use of high-purity columbium in superconductors in 1980 was relatively small, but substantially greater demand for this purpose is expected to develop over the next few years. The superconductivity property of columbium alloys is used to advantage for the construction of extremely powerful magnets, which find application in electrical and nuclear fusion generators. These new generators are much more efficient than conventional generators with copper-wire windings. Also, because of the powerful magnetic field created by the superconductors, many potential applications in electrical devices are being investigated, including new types of motors and ship engines.

Very high-purity columbium oxide is also produced for optical applications. Additions of columbium oxide to optical glass give a high refractive index and thereby allow production of thin lenses for eyeglasses. This characteristic, along with others, such as light weight and durability, enable such lenses to be competitive with plastic lenses.

PRICES

Niobec's pyrochlore price increased by 22 per cent in March 1980 to $US 6.86 per kilogram of contained pentoxide and remained at this quotation for the rest of 1980. The Brazilian pyrochlore price remained unchanged at $US 5.62 per kg, probably because of that country's decision to discontinue exports of columbium concentrates by year-end 1980.

The market for columbite continued strong through to mid-1980. The price, however, softened in the second half of the year as increased mine output began to have an impact on the world supply-demand balance.

In December 1980, the U.S. producer price for high-purity oxide was $US 27.56 per kg, substantially below the price quotation of $US 44 per kg a year earlier.

OUTLOOK

Expansions at columbium mines and the upgrading of process facilities during 1980 greatly enhanced the prospects of future supply availability. Ample supply, together with reasonable and stable prices, will tend to dampen substitution efforts and lead to increased consumption, in part through the development of new applications. In the near-term, the slowdown in steel demand will have an adverse effect on the consumption of ferrocolumbium. However, the use of ferrocolumbium in steelmaking is gaining favour and this trend should more than make up for the state of doldrums which has existed in the steel industry over the past few years. In the medium- to long-term, the demand for columbium steels will increase substantially to fulfill material specifications for new worldwide energy developments and defence applications. Also, automobile manufacturers are increasingly depending upon HSLA steels as part of the general weight reduction program in the industry.

Tantalum

PRODUCTION IN CANADA

Canada is the largest producer of tantalite ores, one of the major sources of tantalum. Canadian production in 1980 was 140 tonnes (t) of tantalum pentoxide (Ta_2O_5) contained in concentrates, a 10 per cent decrease from the previous year. Concentrate shipments during 1980 totalled 127 t compared with the 1979 figure of 159 t of contained tantalum pentoxide. Tantalum is produced in Canada by the Tantalum Mining Corporation of Canada Limited (Tanco) from an underground mine at Bernic Lake, Manitoba. Late in 1980 Tanco completed a flotation plant addition and mill modification work. The mill expansion enabled the company to reprocess about 68 000 t of mill tailings during the summer months and treat 159 000 t of ore, approximately the same volume as treated in previous years, during the remainder of the year.

The large tonnage of tailings stockpiled at Bernic Lake has a tantalum pentoxide grade of about 0.07 per cent. This compares with the average grade of the underground ore currently being mined which typically assays 0.12 per cent Ta_2O_5. The retreatment of tailings by flotation recovered about 50 per cent of the contained tantalum and produced a 20 to 25 per cent tantalum pentoxide product. Standard concentrates from Tanco assay over 35 per cent Ta_2O_5. Due to the overall lower grade of ore being processed, the nominal capacity for producing tantalum at the enlarged facility will be increased only by about 10 per cent.

About 60 per cent of Tanco concentrates is sold under long-term contract to Kawecki Berylco Industries, Inc. (KBI) of Reading, Pennsylvania, which further processes the concentrates at a plant in Boyertown, Pa. KBI owns 37.5 per cent of Tanco, Hudson Bay Mining and Smelting Co., Limited 37.5 per cent, and Manitoba Development Corporation, a Crown agency of the Manitoba government, 25 per cent.

A 1980 drilling program by Placer Development Limited, on the Thor Lake property, Yellowknife area of the Northwest Territories, indicated a large tonnage of very fine-grained tantalum and columbium mineralization. The Thor property, jointly owned by Highwood Resources Ltd. and Calabras (Canada) Ltd., was optioned in March, 1980 to Placer. Under the terms of the option, Placer can earn a 55 per cent interest in the property by spending $4 million on exploration and development over a five-year period. Also, Placer intends to carry out metallurgical testing to determine the recoverability of the metals.

WORLD DEVELOPMENTS

In 1980, mine production of tantalum pentoxide in the western world was about 1 500 t, an increase of 7 per cent over 1979. Over one-half of the source material came from tin-slags and low-ratio columbites and struverites, with Thailand continuing to be the largest single source of supply in 1980.

The supply increase, stimulated by the record-high tantalum prices, resulted mainly from mine expansion, expanded secondary processing and stepped-up scrap recycling. Significant production increases were recorded in Brazil, Australia and Thailand.

Brazil's sharply increased tantalite output in 1980 was the dominant factor in the reversal of the supply situation during the year. Exports from Brazil more than doubled to 72 t of contained tantalum pentoxide in the first five months of 1980 compared with the same period of a year earlier. The production record in Brazil was due to more mining companies entering the industry and to improved recoveries at existing mines.

Australia, the world's third-largest tantalite producer, also augmented its output significantly in 1980. Although tantalum production from the surface mining operations of Greenbushes Tin N.L. of Perth was lower during the year, additional production was derived from a solvent extraction plant, completed in 1979, which treats tantalum-rich slags from an electric-furnace smelter. The company also had under construction a tailings retreatment plant, scheduled to come on stream in February, 1981. This facility plus the slag retreatment plant will double Greenbushes' annual capacity of oxide to 82 t in 1981 and increase it still further to 107 t in 1983.

In October, 1980, Greenbushes announced the discovery of a major tin-tantalum deposit adjacent to the company's open-pit mine in Western Australia. The deposit was reported to contain 21.8 million t of ore grading 0.11 per cent tin, 0.044 per cent Ta_2O_5 and 0.031 per cent Cb_2O_5. At the end of 1980 the company was negotiating a long-term sales contract for production that could begin in 1981. The capital cost of the project would be about $US 60 million for an initial annual capacity of 68 t of tantalite. Full mine development could be completed in 1986 and yield four or five times the initial output if markets warrant the expansion.

Thailand and Malaysia continued to be the world's major tantalum producers, with tantalum-bearing slags being the main source of the metal in both countries. In August, 1980 the Thailand government granted Thailand Tantalum Industry Corp. (TTIC), a locally owned venture, exclusive production rights for eight years to upgrade tantalum oxide from tin slags. The government also approved a proposal by TTIC to build a $US 13.4 million smelter to produce 300 tpy of tantalum and columbium oxides. Exports of tantalum-bearing tin slags from Thailand will be banned beginning in mid-1982, a year before the planned start-up of the TTIC smelter.

The People's Republic of China, a relatively new supplier to the world tantalum market, continued to ship tantalite to the U.S. market in 1980. Exports of synthetic tantalite from West Germany during the year were significantly higher. West Germany, which produces synthetic tantalite from imported tin-slags, increased shipments from stocks in an attempt to stabilize the market.

CONSUMPTION

Western world tantalum consumption of 1 497 t of pentoxide remained at about the same level as in 1979. The minimal growth in demand was partly due to the recession in the United States and partly to attempts by manufacturers to cut back the amount of tantalum being used. The United States remained the largest tantalum consumer, accounting for 60 per cent of the western world's consumption while Europe consumed about 30 per cent and Japan about 6 per cent.

The capacitor industry remained the major market for tantalum. More than one-half of world production is consumed in capacitor manufacturing. Because of the high cost of tantalum powder, capacitor manufacturers in 1980 used less tantalum per unit of capacitor by resorting to high capacitance value (CV) powder. Furthermore, relatively few tantalum capacitors were designed into new equipment, with the exception of military applications, because less-costly alternatives such as aluminum electrolytic and monolithic ceramic capacitors were available. A major growth in tantalum capacitor usage has been in dipped and moulded devices. On the other hand, there was a substantial reduction in the use of tantalum capacitors in automobile radios and engine control devices as manufacturers strove to reduce costs.

Consumption declined in the cemented carbide industry, the second most important market for tantalum, in part because tool manufacturers were adopting coating processes in preference to alloys for some cutting tools. Also, some cost-cutting trends were evident in the cemented carbide industry, particularly in the United States.

These trends range from optimized usage of tantalum and partial substitution to the development of completely new material systems. In addition, with the incentive of high prices, a new recycling process has been developed to produce contamination-free tantalum materials for reuse in the carbide industry, a significant improvement over the previous practice of restricting used carbides to lower quality applications.

Tantalum is also used for its non-corrosive properties in the petroleum and chemical industries, and as a component in high-temperature jet engine alloys. Applications in these areas, though small in comparison, are fast-growing owing to an evolving society which is more conscientious about conserving energy and protecting the environment.

PRICES

Tantalum continued its upward price trend at the beginning of 1980. In response to a situation of strong demand and tight supply, the producer price, in terms of contained pentoxide, was raised in January to $US 193 from $US 165 a kilogram and to $US 226 a kilogram in April. The merchant spot price for pentoxide was reported as high as $US 344 a kilogram. The market softened by the beginning of the summer, with a decline in demand and an increase in ore exports, especially from Brazil. While the merchant market price declined to a range of $US 227-238 a kilogram by November, the producer price remained at $US 226 a kilogram for the remainder of 1980.

OUTLOOK

Supplies of tantalum materials should be adequate to meet stable demand during the next few years. Increases in tantalum production through expansion at current producing sources, the doubling of slag-upgrading facilities and the development potential for new sources in Australia and China should provide the much-needed assurance of continuing supply. The demand for tantalum is expected to stay level in the short- to medium-term and the price may soften somewhat. However, the price is unlikely to fall significantly because a considerable portion of the world's tantalum will be derived from high cost tin-slag operations in Thailand and Malaysia. In the long-term, the consumption of tantalum could increase substantially with the development of a new generation of jet engines designed to operate at higher temperatures and with greater fuel efficiency. The introduction of these engines has been delayed to some extent because of the constraints on tantalum availability.

PRICES

The prices below are in U.S. currency and were quoted in **Metals Week** and **American Metal Market** in December 1979 and 1980

	1979	1980
	($US)	
Columbium ore		
Columbite, per kilogram of pentoxide, cif US ports	22.04 - 26.46	19.84 - 24.25
Brazilian pyrochlore, per kilogram Cb_2O_5 fob shipping point, contract only	5.62	5.62
Ferrocolumbium, per kilogram Cb, fob shipping point		
Low alloy	11.95 - 12.63	13.71 - 14.00
High purity alloy	66.47 - 78.82	66.47 - 68.12
Columbium metal, per kilogram 99.5-99.8%, fas shipping point		
Reactor ingot	116.84 - 132.28	99.21 - 132.28
Reactor powder	122.36 - 139.99	110.23 - 143.30
Tantalum ore		
Tantalite, per kilogram of pentoxide, Tanco price	165.34	225.97
Tantalum metal, per kilogram, fob shipping point depending on size of lot		
U.S. powder	329.70	440.92 - 548.95
U.S. rod 99.9% Ta	412.26 - 551.16	507.06 - 685.64

cif - cost, insurance and freight; fob - free on board; fas - free alongside ship.

TARIFFS

CANADA:

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
32900-1	Columbium and tantalum ores and concentrates	free	free	free	free
35120-1	Columbium (niobium) and tantalum metal and alloys in powder, pellets, scrap, ingots, sheets, plates, strips, bars, rods, tubing or wire for use in Canadian Manufacturing (expires June 30, 1981)	free	free	25	free
37506-1	Ferrocolumbium, ferrotantalum, ferro-tantalum-columbium	free	5	5	free

MFN Reductions under GATT (effective January 1 of year given)

Item No.	1980	1981	1982	1983	1984	1985	1986	1987
				(%)				
37506-1	5.0	5.0	4.8	4.7	4.5	4.3	4.2	4.0

UNITED STATES:

Item No.		
601.21	Columbium ore	free
601.42	Tantalum ore	free

		1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
628.15	Columbium metal, unwrought, and waste and scrap (duty on waste and scrap suspended to June 30, 1981)	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
628.17	Columbium, unwrought alloys	7.2	6.9	6.5	6.2	5.9	5.6	5.2	4.9
628.20	Columbium metal, wrought	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5
629.05	Tantalum metal, unwrought and waste and scrap (duty on waste and scrap suspended to June 30, 1981)	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
629.07	Tantalum, unwrought alloys	7.2	6.9	6.5	6.2	5.9	5.6	5.2	4.9
629.10	Tantalum metal, wrought	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated 1980, USITC Publication 1011; U.S. Federal Register, Vol. 44, No. 241.

Copper

D.A. CRANSTONE

The most notable events concerning copper in Canada in 1980 were the higher copper prices that prevailed early in the year (chiefly the result of speculative activity in metal markets related to the high gold price), the ongoing construction of several new copper mine and expansion projects, and the announcement of several more new mine developments.

CANADIAN DEVELOPMENTS

Canadian production of copper in all forms in 1980 rose 11.3 per cent from that in 1979 (Table 1) when production was affected by strikes at the Sudbury operations of Inco Limited and the Mines Gaspé Division of Noranda Mines Limited.

Atlantic Provinces

Production continued through 1980 at the Buchans operation of ASARCO Incorporated, where it had been expected that ore reserves would be exhausted before year-end. Consolidated Rambler Mines Limited carried out a milling test on material from the footwall mineralized zone that had been exposed in 1979 by a drift on the 550-metre (m) level. The conclusion is that this zone cannot be mined economically at the present time.

Quebec

Campbell Resources Inc. (formerly Campbell Chibougamau Mines Ltd.) commenced a $6.3 million project at the Henderson mine, involving the sinking of a new internal shaft at least 240 m below the present 600 m bottom level. By the end of September, this project had already added 400 000 tonnes (t) of new ore reserves, with potential for considerably more. A corporate reorganization was announced on October 30, under which Camchib Resources Inc. (formerly C.M. & S. Mines Inc.) acquired the mining assets of Campbell Resources and became an operating subsidiary of the latter as of January 1, 1981.

Corporation Falconbridge Copper commenced production from the Corbet mine at the company's Lake Dufault Division in January. Production, initially at a rate of 600 tpd, is to increase as that from the Millenbach mine decreases. The Millenbach is expected to be exhausted in 1981.

Noranda Mines Limited is spending $3.8 million to modify the Horne concentrator, at Noranda, to treat ore from the New Insco Mines Ltd. and Les Mines Gallen Limitée deposits. Another $4 million is being spent on the New Insco property. New Insco production will be about 122 000 tpy of ore and employment will total about 40. Noranda is also developing a deposit not far from Matagami that was optioned from Phelps Dodge Corporation of Canada, Limited, with production to begin early in 1982.

Noranda plans to spend $35 million to overhaul and modify the Horne smelter. Electricity will replace oil as the major energy source. A new 450 tpd oxygen plant will help to decrease unit fuel requirements and increase capacity of the continuous reactor, permitting the closure of one of the two operating reverberatory furnaces. Some 41 fewer employees will be required at the modified smelter. The new equipment is expected to be in operation early in 1983.

TABLE 1. CANADA, COPPER PRODUCTION, TRADE AND CONSUMPTION, 1979 AND 1980

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Production[1]				
British Columbia	272 163	645,293,493	276 223	723,697,000
Ontario	192 946	457,472,114	233 297	611,232,000
Quebec	80 231	190,226,950	101 455	265,809,000
Manitoba	58 303	138,235,220	65 747	172,255,000
Yukon	7 778	18,442,058	10 505	27,522,000
New Brunswick	10 647	27,591,109	9 651	25,286,000
Newfoundland	8 223	19,495,288	5 795	15,182,000
Saskatchewan	5 695	13,501,852	5 443	14,261,000
Northwest Territories	397	941,732	300	787,000
Total	636 383	1,511,199,816	708 416	1,856,031,000
Refined	397 263	..	505 238	..
Exports				
Copper in ores, concentrates and matte				
Japan	233 502	364,464,000	178 883	353,761,000
Norway	20 592	25,522,000	19 723	50,126,000
USSR	20 773	42,567,000	24 188	27,830,000
Taiwan	-	-	10 628	19,032,000
People's Rep. of China	-	-	7 602	13,471,000
Romania	-	-	6 445	11,692,000
Spain	16 311	19,235,000	13 587	10,490,000
South Korea	9 025	13,736,000	5 153	9,297,000
West Germany	7 116	10,293,000	5 515	8,251,000
Finland	-	-	3 025	6,638,000
United States	5 091	7,710,000	3 179	6,356,000
Other countries	2 456	3,493,000	8 118	6,497,000
Total	314 866	487,020,000	286 046	523,441,000
Copper in slag, skimmings and sludge				
United States	243	115,000	306	37,000
Spain	-	-	17	7,000
Total	243	115,000	323	44,000
Copper scrap (gross weight)				
United States	11 840	21,446,000	13 939	30,893,000
Spain	359	653,000	1 546	3,798,000
Belgium and Luxembourg	929	1,807,000	1 672	2,891,000
Netherlands	18	25,000	589	1,387,000
Japan	198	277,000	450	779,000
Taiwan	191	100,000	387	578,000
West Germany	416	804,000	301	568,000
Korea, South	1 456	2,756,000	237	491,000
Other countries	469	517,000	650	1,150,000
Total	15 876	28,385,000	19 771	42,535,000
Brass and bronze scrap (gross weight)				
United States	8 944	12,853,000	9 106	14,435,000
Belgium and Luxembourg	2 387	3,521,000	3 119	5,044,000
India	1 468	1,794,000	1 049	1,458,000
Italy	198	250,000	965	1,428,000
West Germany	1 093	1,928,000	694	1,370,000
Japan	940	1,189,000	526	816,000
Spain	247	214,000	393	773,000

TABLE 1. (cont'd.)

	1979		1980^{p}	
	(tonnes)	($)	(tonnes)	($)
Brass and bronze scrap (gross weight) (cont'd)				
Taiwan	86	96,000	298	399,000
United Kingdom	35	43,000	273	393,000
Netherlands	251	438,000	95	132,000
Other countries	708	883,000	196	312,000
Total	16 357	23,209,000	16 714	26,560,000
Copper alloy scrap, nes (gross weight)				
Belgium and Luxembourg	2 993	4,261,000	2 019	3,425,000
United States	3 067	3,429,000	2 557	3,376,000
Taiwan	940	215,000	1 305	295,000
Netherlands	78	106,000	131	221,000
United Kingdom	59	77,000	145	207,000
West Germany	147	254,000	89	122,000
Other countries	879	693,000	113	118,000
Total	8 163	9,035,000	6 359	7,764,000
Copper refinery shapes				
United States	71 042	170,573,000	126 697	329,150,000
United Kingdom	54 949	142,204,000	74 559	193,876,000
West Germany	13 206	33,460,000	29 495	76,955,000
Belgium and Luxembourg	10 406	26,446,000	25 611	60,366,000
Netherlands	2 573	6,980,000	16 010	43,213,000
France	10 457	26,409,000	16 487	42,347,000
Italy	6 793	17,064,000	11 640	30,589,000
Brazil	516	1,075,000	10 166	25,829,000
Sweden	5 778	14,406,000	7 565	19,375,000
India	-	-	7 637	18,601,000
Greece	1 593	4,104,000	2 259	5,810,000
Portugal	1 101	2,722,000	2,249	5,761,000
Other countries	12 708	23,824,000	4 653	10,748,000
Total	191 122	469,267,000	335 028	862,620,000
Copper bars, rods and shapes, nes				
United States	5 248	15,561,000	7 870	23,502,000
Venezuela	1 602	3,992,000	1 980	5,949,000
Pakistan	1 565	3,178,000	1 843	5,104,000
Bangladesh	1 250	2,964,000	921	2,855,000
Dominican Republic	541	1,300,000	773	2,277,000
India	-	-	474	1,215,000
Cuba	-	-	480	1,178,000
Colombia	200	560,000	440	1,120,000
Nigeria	870	2,521,000	300	1,046,000
Other countries	388	663,000	424	1,146,000
Total	11 664	30,739,000	15 505	45,392,000
Copper plates, sheet and flat products				
United States	6 464	20,901,000	3 874	14,445,000
Venezuela	233	624,000	131	558,000
Ecuador	6	24,000	16	71,000
Other countries	49	147,000	12	58,000
Total	6 752	21,696,000	4 033	15,132,000

TABLE 1. (cont'd.)

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Copper pipe and tubing				
United States	5 494	17,435,000	3 524	12,805,000
West Germany	980	2,779,000	1 329	4,551,000
Spain	644	1,890,000	1 140	4,245,000
Israel	928	2,637,000	783	2,702,000
United Kingdom	441	1,469,000	324	1,307,000
Netherlands	51	203,000	233	1,077,000
France	11	45,000	126	538,000
Ireland	48	146,000	124	491,000
Italy	121	378,000	137	377,000
USSR	-	-	51	370,000
Other countries	1 013	3,730,000	241	949,000
Total	9 731	30,712,000	8 012	29,412,000
Copper wire and cable (not insulated)				
United States	909	1,927,000	211	357,000
United Kingdom	-	-	36	125,000
Libya	-	-	17	50,000
Trinidad-Tobago	10	50,000	7	31,000
Other countries	558	1,137,000	5	30,000
Total	1 477	3,114,000	276	593,000
Copper alloy shapes and sections				
United States	12 458	34,419,000	7 021	23,419,000
Venezuela	117	356,000	22	84,000
West Germany	-	-	18	64,000
Netherlands	-	-	14	54,000
Australia	138	395,000	16	49,000
Ecuador	23	64,000	12	48,000
Other countries	119	344,000	16	82,000
Total	12 855	35,578,000	7 119	23,800,000
Copper alloy pipe and tubing				
United States	3 300	12,136,000	2 329	9,693,000
West Germany	62	219,000	77	300,000
USSR	-	-	29	212,000
Taiwan	-	-	26	189,000
Portugal	18	88,000	28	127,000
New Zealand	3	17,000	20	95,000
United Kingdom	50	204,000	23	93,000
Argentina	-	-	12	87,000
Other countries	553	2,300,000	74	387,000
Total	3 986	14,964,000	2 618	11,183,000
Copper alloy wire and cable, not insulated				
United States	127	475,000	114	567,000
Saudi Arabia	-	-	61	171,000
New Zealand	16	72,000	18	102,000
South Africa	20	68,000	7	34,000
Other countries	7	32,000	6	7,000
Total	170	647,000	206	881,000
Copper and alloy fabricated materials, nes				
United States	1 289	4,570,000	1 170	4,867,000
Belgium-Luxembourg	10	36,000	108	1,046,000
United Kingdom	191	531,000	153	453,000

TABLE 1. (cont'd.)

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Copper and alloy fabricated materials, nes (cont'd)				
Dominican Republic	--	1,000	91	252,000
Japan	-	-	14	139,000
Brazil	-	-	50	138,000
Other countries	143	481,000	124	589,000
Total	1 633	5,619,000	1 710	7,484,000
Insulated wire and cable[2]				
United States	12 942	46,298,000	13 880	55,428,000
Saudi Arabia	4 123	12,332,000	3 871	14,842,000
USSR	138	395,000	664	6,293,000
Trinidad-Tobago	311	983,000	1 409	5,105,000
Puerto Rico	36	185,000	886	3,266,000
Pakistan	3 231	5,679,000	1 344	3,254,000
Algeria	192	418,000	214	1,120,000
Dominican Republic	424	1,437,000	223	1,006,000
Japan	17	173,000	15	591,000
Ireland	-	-	186	569,000
Other countries	3 404	9,878,000	2 137	9,201,000
Total	24 818	77,778,000	24 829	100,675,000
Total exports of copper and products	..	1,237,878,000	..	1,697,516,000
Imports				
Copper in ores and concentrates	2 640	3,248,000	10 929	15,142,000
Copper scrap	26 538	34,975,000	28 046	41,173,000
Copper refinery shapes	32 541	73,901,000	13 465	31,634,000
Copper bars, rods and shapes, nes	800	1,810,000	761	2,265,000
Copper plates, sheet strip and flat products	1 118	3,603,000	1 316	5,016,000
Copper pipe and tubing	2 384	8,099,000	2 620	10,413,000
Copper wire and cable, not insulated	1 701	5,096,000	980	4,017,000
Copper alloy scrap (gross weight)	8 905	8,731,000	7 006	8,250,000
Copper powder	569	1,737,000	386	1,124,000
Copper alloy refinery shapes, bars and sections	9 814	22,797,000	10 282	26,110,000
Brass plates, sheet and flat products	4 192	9,946,000	3 621	10,960,000
Copper alloy plates, sheets, strip and flat products	1 078	4,211,000	2 428	12,449,000
Copper alloy pipe and tubing	2 486	9,693,000	2 158	10,071,000
Copper alloy wire and cable, not insulated	764	2,989,000	778	2,877,000
Copper and alloy fabricated material, nes	2 040	9,844,000	2 293	11,056,000
Insulated wire and cable	..	52,228,000	..	52,507,000
Copper oxides and hydroxides	303	766,000	295	765,000
Copper sulphate	542	464,000	142	176,000
Copper alloy castings	583	2,457,000	635	2,276,000
Total imports of copper and products	..	256,595,000	..	248,281,000
Consumption[3]				
Refined	210 689	..	195 124	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Blister copper plus recoverable copper in matte and concentrate exported. [2] Includes small quantities of non-copper wire and cable, insulated. [3] Producers' domestic shipments, refined copper.

- Nil; P Preliminary; .. Not available or not applicable; nes Not elsewhere specified; -- Too small to be expressed.

At Noranda's Mines Gaspé Division, drilling of the Needle Mountain 'C' zone intersected a promising mineralized horizon at depth, under the town of Murdochville. Rehabilitation of the oxide ore treatment plant, incorporating effluent control, was completed in December, with production expected to be resumed in January 1981.

Construction of the $85 million, 1 500 tpd mine and concentrator at Les Mines Selbaie joint venture of Selco Inc. and Hudson's Bay Oil and Gas Company Limited is under way, with initial production scheduled for the third quarter of 1981. A further program of test drilling was carried out during 1980 on the A-2 zone, approximately 1 km east of the B-zone.

Because of high metal prices, Madeleine Mines Ltd. decided to extend mining to mid-1983. Although the results of an underground exploration program were disappointing, surface exploration is to continue in the immediate vicinity of the mine.

Lemoine Mines Limited announced that ore reserves at the mine are likely to be exhausted by mid-1982.

Ontario

Texasgulf Inc. is to begin operating its new Mitsubishi Metal Corporation-type continuous copper smelter-refinery in 1981, and has announced tentative plans to raise the capacity of this plant from 59 000 t to as much as 91 000 t of copper annually by using more oxygen in the smelting process. Engineering work and some pile driving for the expansion project were carried out during 1980. The expansion would include new oxygen and sulphuric acid plants and additional refining capacity. A precious metals refinery that will increase Texasgulf's recovery of silver, gold and selenium is tentatively planned for later.

Copper production from the Sudbury operations of Inco Limited, although up from 1979 (when operations had been shut down by a strike until early June), were well below pre-strike levels, owing to production cutbacks resulting from a reduced demand for nickel.

In December, Falconbridge Nickel Mines Limited commenced operation of a new circuit at the Strathcona mill for the production of a high-grade copper concentrate. The company's North Mine was reactivated in the fall.

In the Sturgeon Lake area, production started in October at the Lyon Lake mine, a zinc-lead-silver-gold producer that will yield about 4 000 t of copper in concentrates annually. Development of the company's open-pit "F" Group mine, also at Sturgeon Lake, continued with production scheduled for July 1981. Mattabi Mines Limited announced that preliminary surface drilling at its mine near Sturgeon Lake discovered additional ore, delineation of which was expected to delay the start of underground production until 1981. The life of the open-pit operation has been extended to offset this delay.

Manitoba

Hudson Bay Mining and Smelting Co., Limited announced plans to develop two new mines. A production agreement for the Rod deposit, at Snow Lake, was reached with Falconbridge Nickel Mines Limited and Stall Lake Mines Limited. Hudson Bay will spend some $14.5 million to develop the Rod mine, with production at a rate of 450 tpd scheduled to begin in 1983. The copper-zinc ore will be treated at the Snow Lake concentrator. Hudson Bay also signed a joint venture agreement for the development of the Trout Lake (Embury Lake) copper-zinc deposit, near Flin Flon. Hudson Bay will be the operator and will earn a 44 per cent interest in the venture by spending about $25 million to develop the mine. The other partners are Gränges Exploration AB, and Gränges International Mining (GIM); Outokumpu Oy, of Finland; and Manitoba Mineral Resources Ltd., a Manitoba Crown corporation. Ore is to be treated at the Flin Flon concentrator. Surface work began at Trout Lake in 1980, with production scheduled to commence at 815 tpd in 1982 and to reach rated capacity of 1 630 tpd in 1983. Construction of the Spruce Point mine continued during the year, with production at 655 tpd scheduled for 1982.

At the Ruttan mine of Sherritt Gordon Mines Limited, mining from the open-pit ceased in December, with all ore production now from underground.

British Columbia

Noranda Mines Limited is developing its Goldstream copper-zinc deposit for production by late 1982. Annual production will be about 68 000 t of copper concentrates and 10 500 t of zinc concentrates.

TABLE 2. CANADA, COPPER PRODUCTION, TRADE AND CONSUMPTION, 1970 AND 1975-80

	Production		Exports			Imports	Consumption[2]
	All Forms[1]	Refined	Ore and Matte	Refined	Total	Refined	Refined
				(tonnes)			
1970	610 279	493 261	161 377	265 264	426 641	13 192	215 834
1975	733 826	529 197	314 518	320 705	635 223	10 908	185 198
1976	730 930	510 469	294 823	322 991	617 814	9 124	206 198
1977	759 423	508 767	279 583	294 490	574 073	18 821	203 382
1978	659 380	446 278	282 159	247 727	529 886	21 441	228 694
1979	636 383	397 263	314 866	191 122	505 988	32 541	210 689
1980P	708 416	505 238	286 046	335 028	621 074	13 465	195 124

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Blister copper plus recoverable copper in matte and concentrate exported. [2] Producers' domestic shipments of refined copper.
P Preliminary.

Canada Wide Mines Ltd. (Esso Minerals Canada) reopened the former Granduc mine near Stewart. Plant and mine rehabilitation were completed and production started in the fall. When full production is attained in the next year or two, the concentrator is expected to treat 3 600 tpd of ore. Production also began in September at the Equity Silver Mines Limited silver-copper-gold-antimony mine (operated by Placer Development Limited) south of Houston. Full production will be delayed pending completion of a leach plant in 1981, to remove antimony and arsenic from the copper-silver concentrate. The addition of the leach plant has resulted in the total cost of developing Equity increasing from $107 million to $129 million.

In the Highland Valley area, Teck Corporation commenced production at the Highmont copper-molybdenum mine. One of the two mill circuits began operating in December, with the second circuit expected to be operational in the early spring of 1981. Early in 1980, Teck agreed to transfer a 14 per cent interest in the Highmont project to Metallgesellschaft Canada Limited for $14.4 million. Lornex Mining Corporation Ltd. continued with its concentrator and mine expansion project, designed to increase the Lornex milling rate by 68 per cent. The expansion is expected to begin operation by the summer of 1981.

Valley Copper Mines Limited and Bethlehem Copper Corporation continued studies on the feasibility of production from the Lake Zone copper deposit at a rate of 102 200 tpd. The property could be developed for production in about two and a half years and would be the largest copper mine in Canada. In October, Cominco Ltd. agreed to purchase 1,627,000 shares of Bethlehem from Gulf Resources & Chemical Corporation of Houston, Texas, raising its interest from 39.25 to 65 per cent. Cominco also offered to purchase the 22.84 per cent interest in Bethlehem held by Newmont Mining Corporation, but Newmont indicated that it wants to stay in the Valley Copper project. Control of Bethlehem now gives Cominco control of the entire Lake Zone deposit.

Brenda Mines Ltd. announced that ore reserves at its copper-molybdenum mine west of Peachland had been increased, with the additional tonnage expected to extend the life of the mine by at least five years. Concentrator operations were disrupted for about one month following a major mechanical failure in the primary crusher.

Western Mines Limited began development of the shaft for the new HW orebody. Another new mine (the Price mine) is being prepared for production by late 1981. Both the HW and Price mines are near the existing Lynx and Myra mines, and should add many years to the life of the Buttle Lake operation.

Craigmont Mines Limited expected operation at its copper mines near Merritt to end early in 1981.

TABLE 3. PRINCIPAL COPPER MINES IN CANADA, 1980 AND (1979)

Company and Location	Mill or Mine Capacity	Grade of Ore Milled						Ore Milled	Copper Concentrates Produced	Grade of Copper in Concentrate	Contained Copper Produced[1] In All Concentrates	Destination of Copper Concentrate[2]
		Copper	Zinc	Lead	Nickel	Silver	Gold					
	(tonnes)	(%)	(%)	(%)	(%)	(grams/ tonne)	(grams/ tonne)	(tonnes)	(tonnes)	(%)	(tonnes)	
Newfoundland												
ASARCO Incorporated, Buchans	1 100 (1 100)	0.85 (1.04)	9.38 (11.64)	5.42 (6.51)	- (-)	102.51 (109.71)	0.82 (0.82)	75 296 (113 398)	1 324 (2 526)	24.79 (26.17)	588 (1 104)	9 (9)
Consolidated Rambler Mines Limited, Ming mine, Baie Verte	1 100 (1 100)	3.51 (3.90)	- (-)	- (-)	- (-)	18.55 (23.52)	2.09 (2.67)	164 281 (196 918)	22 184 (28 786)	24.96 (25.43)	5 537 (7 320)	1 (1)
New Brunswick												
Brunswick Mining and Smelting Corporation Limited, No. 6 and No. 12 mines, Bathurst	9 100 (9 100)	0.31 (0.31)	8.80 (8.93)	3.56 (3.61)	- (-)	97.37 (94.97)	- (-)	1 848 036 (2 971 516)	10 344 (16 842)	22.35 (21.69)	3 804 (6 032)	1 (1)
Heath Steele Mines Limited, Newcastle	3 650 (3 650)	0.84 (0.91)	4.34 (4.55)	1.45 (1.53)	- (-)	55.20 (55.20)	1.03 (0.69)	1 252 406 (1 172 737)	26 894 (26 394)	21.21 (23.76)	7 430 (7 805)	1 (1,2)
Quebec												
Campbell Resources Inc., Cedar Bay, Henderson and Main and Gwillim mines, Chibougamau	3 600 (3 600)	0.99 (1.17)	- (-)	- (-)	- (-)	6.86 (7.54)	2.78 (2.26)	390 981 (396 822)	17 894 (22 318)	19.77 (20.00)	3 538 (4 464)	2 (2)
Corporation Falconbridge Copper, Millenbach and Corbet mines, Noranda	1 400 (1 400)	2.70 (3.60)	2.19 (4.90)	- (-)	- (-)	28.80 (48.69)	0.72 (0.89)	475 464 (419 827)	49 208 (55 826)	24.68 (25.90)	12 261 (14 672)	2 (2)

Corporation Falconbridge Copper, Perry, Springer, Cooke mines, Chapais	2 900 (2 900)	1.57 (1.79)	- (-)	- (-)	- (-)	10.29 (12.34)	1.23 (1.34)	964 052 (954 801)	63 946 (68 248)	22.78 (23.79)	14 567 (16 236)	2 (2)
Lemoine Mines Limited (Patino N.V.) Chibougamau	300 (300)	4.71 (5.07)	10.00 (11.61)	- (-)	- (-)	88.80 (92.91)	5.14 (5.25)	104 326 (108 267)	19 234 (22 047)	24.41 (23.70)	4 767 (5 330)	2 (2)
Louvem Mining Company Inc., (SOQUEM), Louvicourt	910 (910)	0.15 (0.04)	3.89 (4.51)	0.11 (0.55)	- (-)	30.38 (137.83)	1.82 (0.93)	224 530 (72 261)	2 433 (-)	7.76 (12.62)	282 (304)	9 (-)
Madeleine Mines Ltd., Ste. Anne des Monts	2 250 (2 250)	0.94 (0.98)	- (-)	- (-)	- (-)	5.14 (6.86)	- (-)	564 738 (297 853)	15 710 (8 832)	31.59 (30.68)	4 963 (2 710)	1 (1)
Noranda Mines Limited Mines Gaspé Div., Copper Mountain and Needle Mountain mines, Murdochville	30 800 (30 700)	0.52 (0.51)	- (-)	- (-)	- (-)	3.31 (3.16)	0.06 (0.07)	10 226 322 (5 635 596)	208 311 (107 564)	22.48 (23.10)	47 375 (24 859)	1 (1)
Noranda Mines Limited Matagami Division Mattagami, Orchan, Norita and Radiore No. 2 mines	(4 100) (4 000)	(0.77) (0.73)	(4.81) (5.37)	(-) (-)	(-) (-)	21.39 (26.85)	0.51 (0.58)	1 328 360 (1 329 025)	37 310 (32 262)	22.50 (23.54)	8 906 (8 346)	2 (2)
Patino Mines (Québec) Limited, Copper Rand, Copper Cliff, Portage mines, Chibougamau	2 500 (2 500)	1.68 (1.64)	- (-)	- (-)	- (-)	9.22 (9.50)	2.95 (3.19)	615 035 (606 995)	52 264 (48 080)	19.29 (19.97)	10 082 (9 602)	2 (2)
Ontario												
Corporation Falconbridge Copper, Sturgeon Lake Joint Venture, Sturgeon Lake	1 100 (1 100)	1.46 (2.17)	5.89 (8.70)	1.05 (1.23)	- (-)	131.66 (169.71)	0.48 (0.62)	371 623 (373 953)	20 462 (33 861)	21.49 (21.88)	4 580 (7 742)	2 (2)

TABLE 3. (cont'd)

Company and Location	Mill or Mine Capacity (tonnes)	Grade of Ore Milled Copper (%)	Zinc (%)	Lead (%)	Nickel (%)	Silver (grams/	Gold (grams/	Ore Milled (tonnes)	Copper Concentrates Produced (tonnes)	Grade of Copper in Concentrate (%)	Contained Copper Produced[1] In All Concentrates (tonnes)	Destination of Copper Concentrate[2]
Ontario (cont'd)												
Falconbridge Nickel Mines Limited, Falconbridge, East Onaping, Lockerby and Strathcona mines, Sudbury	10 300 (10 300)	0.94 (0.85)	- (-)	- (-)	1.20 (1.23)	3.43 (3.4)	0.07 (0.07)	2 182 765 (2 130 991)	.. (..)	.. (..)	19 343 (20 515)	4,5 (4,5)
Inco Metals Company (Inco Limited), Clarabelle, Coleman, Copper Cliff South, Creighton, Frood, Garson, Levack, Little Stobie, Stobie and McCreedy West mines, Sudbury	49 400[4] (49 400)[4]	1.30 (1.39)	- (-)	- (-)	1.39 (1.40)	4.46[e] (..)	0.17[e] (..)	10 608 827 (5 339 227)	.. (..)	.. (..)	130 844[3] (69 921)	3 (3)
Mattabi Mines Limited, Sturgeon Lake	2 700 (2 700)	0.44 (0.55)	7.24 (6.91)	0.87 (0.77)	- (-)	106.63 (97.71)	- (0.38)	846 940 (945 015)	8 676 (15 364)	22.79 (22.71)	3 149 (4 463)	2 (2)
Noranda Mines Limited, Geco Division, Manitouwadge	4 500 (4 500)	1.47 (1.82)	3.32 (3.24)	0.14 (0.11)	- (-)	60.79 (58.97)	0.10 (0.10)	1 358 317 (1 475 841)	64 205 (90 776)	27.93 (26.91)	18 798 (25 254)	2 (2)
Noranda Mines Limited, Lyon Lake mine, Sturgeon Lake	92 024 (-)	0.86 (-)	5.48 (-)	0.61 (-)	- (-)	98.4 (-)	- (-)	92 000 (-)	..[5] (-)	..[5] (-)	520 (-)	2 (-)
Pamour Porcupine Mines, Limited, Schumacher Division, mill Timmins	2 700 (2 700)	0.25 (0.25)	- (-)	- (-)	- (-)	2.85 (3.43)	2.19 (2.96)	845 982 (728 079)	7 494 (6 857)	23.05 (22.56)	1 727 (1 547)	2 (2)

Selco Inc., South Bay mine, Uchi Lake	450 (450)	1.48 (1.44)	8.79 (10.75)	- (-)	- (-)	65.49 (63.77)	- (-)	117 290 (132 923)	6 164 (6 893)	24.88 (25.33)	1 642 (1 836)	2 (2)
Teck Corporation, Silverfields Div., Cobalt	250 (250)	0.60 (0.60)	- (-)	- (-)	0.25 (0.26)	171.43 (308.57)	- (-)	76 041 (75 392)	- (-)	- (-)	22 (35)	- (-)
Texasgulf Inc., Kidd Creek mine, Timmins	9 100 (9 100)	1.83 (1.95)	5.78 (5.47)	0.15 (0.20)	- (-)	86.36 (76.03)	- (-)	3 899 575 (3 680 858)	256 835 (259 404)	24.96 (25.18)	67 826 (68 379)	2 (2)
Union Minière Explorations and Mining Corporation Limited, Thierry mine, Pickle Lake	3 600 (3 600)	1.20 (1.15)	- (-)	- (-)	0.11 (0.11)	7.89 (8.23)	- (..)	1 080 000 (966 291)	39 732 (36 672)	30.00 (26.82)	11 920 (9 835)	2 (2)
Manitoba-Saskatchewan												
Hudson Bay Mining and Smelting Co., Limited, Anderson, Chisel, Flin Flon (including Saskatchewan portion), Ghost, Osborne, Stall, White Lake, Centennial and Western mines, Flin Flon and Snow Lake	10 700 (7 250)	2.11 (2.23)	2.61 (3.55)	0.19 (0.14)	- (-)	18.39 (17.3)	1.21 (1.12)	1 701 662 (1 701 000)	177 428 (185 609)	18.28 (17.12)	32 950 (32 296)	6 (6)
Inco Metals Company, Pipe and Thompson mines, Thompson district	12 700 (12 700)	0.13 (0.14)	- (-)	- (-)	1.76 (1.81)	2.74^{e} 2.74^{e}	0.10^{e} 0.10^{e}	2 557 454 2 269 680	.. (..)	.. (..)	2 917 (..)^{6}	3 (3)
Sherritt Gordon Mines Limited, Fox mine, Lynn Lake area	2 700 (2 700)	1.40 (1.19)	1.56 (4.69)	- (-)	- (-)	6.51^{e} (4.69)	0.27^{e} (0.17)	784 011 (722 500)	38 479 (31 793)	25.29 (25.84)	9 951 (8 477)	6 (6)
Ruttan mine, Leaf Rapids area	9 100 (9 100)	1.36 (1.39)	1.02 (1.17)	- (-)	- (-)	6.51^{e} (5.60)	0.27^{e} (0.21)	2 311 444 (2 094 159)	105 384 (96 923)	27.05 (26.99)	28 840 (26 614)	2,6 (2,6)

TABLE 3. (cont'd)

Company and Location	Mill or Mine Capacity (tonnes)	Grade of Ore Milled: Copper (%)	Zinc (%)	Lead (%)	Nickel (%)	Silver (grams/tonne)	Gold (grams/tonne)	Ore Milled (tonnes)	Copper Concentrates Produced (tonnes)	Grade of Copper in Concentrate (%)	Contained Copper Produced[1] In All Concentrates (tonnes)	Destination of Copper Concentrate[2]
British Columbia												
Bethlehem Copper Corporation, Highland Valley	18 000 (18 000)	0.38 (0.41)	- (-)	- (-)	- (-)	1.78 (2.13)	0.03 (0.04)	6 182 347 (6 536 861)	67 349 (52 482)	28.83 (40.16)	19 417 (21 007)	13 (10,13)
Molybdenum grades of ore milled: 1980, 0.005% Mo; 1979, 0.006%												
Brenda Mines Ltd., Peachland	27 200 (27 000)	0.13 (0.14)	- (-)	- (-)	- (-)	1.10 (1.27)	0.02 (0.02)	9 126 857 (9 075 720)	32 390 (36 672)	29.03 (29.95)	9 403 (10 727)	10,12 (10,12)
Molybdenum grades of ore milled: 1980, 0.033% Mo; 1979, 0.036% Mo.												
Canada Wide Mines Ltd., Granduc mine, Stewart	3 600 (-)	1.28 (-)	- (-)	- (-)	- (-)	.. (-)	.. (-)	72 586 (-)	3 464 (-)	27.64 (-)	869 (-)	.. (-)
Craigmont Mines Limited, Merritt	5 300 (5 300)	0.63 (0.86)	- (-)	- (-)	- (-)	- (-)	- (-)	1 950 551 (1 924 570)	39 773 (48 849)	27.80 (28.32)	11 507 (14 117)	10,13 (10,12,13)
DeKalb Mining Corporation, Highland Valley	635 (-)	1.93 (-)	- (-)	- (-)	- (-)	20.19 (-)	0.39 (-)	48 234 (-)	2 444 (-)	36.25 (-)	886 (-)	.. (-)
Equity Silver Mines Limited, Houston	4 550 (-)	0.38 (-)	- (-)	- (-)	- (-)	126.86 (-)	0.96 (-)	448 000 (-)	7 470 (-)	16.07 (-)	1 200 (-)	10 (-)
Falconbridge Nickel Mines Limited, Tasu (Wesfrob) mine Tasu Harbour, Queen Charlotte Islands	7 300 (7 300)	0.27 (0.37)	- (-)	- (-)	- (-)	3.12 (4.46)	0.07 (0.10)	996 432 (1 009 247)	10 689 (15 691)	21.13 (20.35)	2 259 3 193	10 (10,13)
Iron grade of ore milled: 1980, 47%; 1979, 45%												
Gibraltar Mines Ltd. McLeese Lake, Cariboo District	37 300 (36 300)	0.38 (0.42)	- (-)	- (-)	- (-)	0.69 (0.96)	- (-)	12 643 870 (10 446 035)	135 199 (128 455)	27.43 (28.25)	37 085 (36 288)	6,10,13 (6,10,13)
Molybdenum grade of ore milled: 1980, 0.011% Mo; 1979, 0.010% Mo												

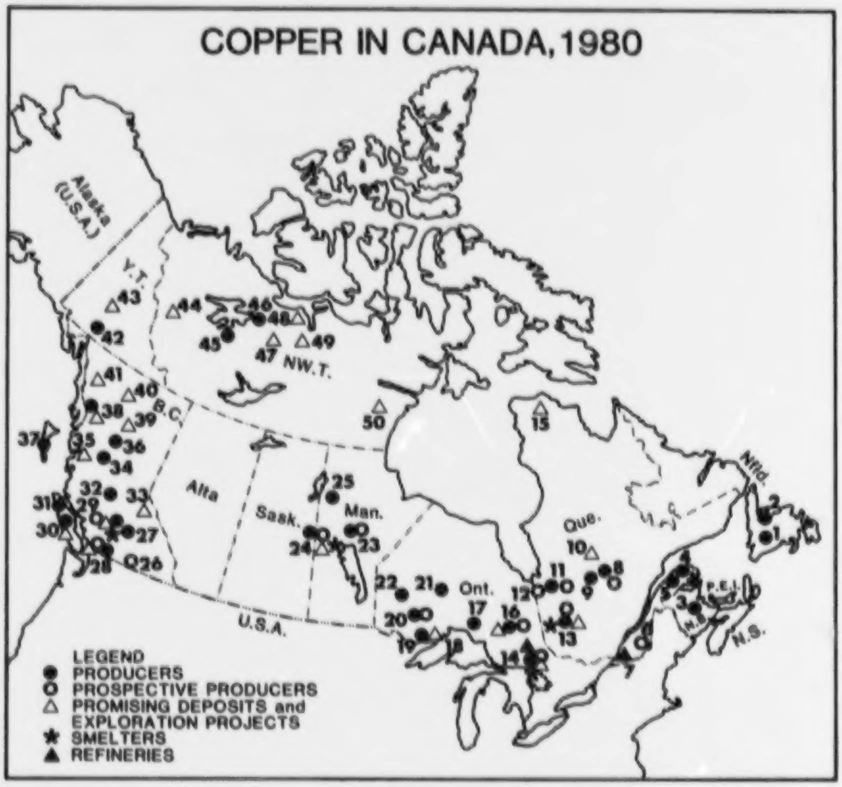
Lornex Mining Corporation Ltd., Lornex mine, Highland Valley	44 500 (44 500)	0.41 (0.43)	- (-)	- (-)	- (-)	2.06 (2.06)	- (-)	16 037 591 (16 126 103)	193 542 (200 805)	30.58 (31.67)	59 185 (63 595)	10 (9,10,13)
Molybdenum grade of ore milled: 1980, 0.017% Mo; 1979, 0.016%												
Newmont Mines Limited, Similkameen Div., Princeton	22 000 (22 000)	0.46 (0.44)	- (-)	- (-)	- (-)	1.47 (0.62)	0.34 (0.17)	6 612 470 (7 034 952)	90 422 (94 677)	29.09 (28.10)	26 304 (26 604)	10 (10)
Noranda Mines Limited (Babine Division), Bell Copper mine, Babine Lake	15 400 (15 400)	0.41 (0.44)	- (-)	- (-)	- (-)	.. (..)	0.34 (0.27)	5 012 196 (5 073 909)	62 909 (53 874)	26.53 (27.18)	16 690 (14 643)	2 (2)
Granisle mine, Babine Lake	(12 700) (12 700)	0.39 (0.45)	- (-)	- (-)	- (-)	2.06 (2.40)	0.21 (0.24)	3 936 725 (4 382 909)	40 062 (50 111)	33.10 (34.86)	13 261 (17 469)	2,10,13 (10,11,13)
Northair Mines Ltd., Brandywine mine	270 (270)	0.50 (0.50)	2.15 (1.50)	1.38 (0.91)	- (-)	32.33 (26.33)	8.37 (11.35)	71 478 (91 587)	- (-)	- (-)	117 (99)	- (-)
Teck Corporation, Afton mine, Kamloops	7 800 (7 800)	1.05 (1.06)	- (-)	- (-)	- (-)	5.07 (4.90)	0.65 (0.79)	2 739 799 (2 822 528)	43 014 (42 862)	58.54 (61.01)	25 179 (26 149)	8 (8)
Utah Mines Ltd., Island Copper mine, Coal Harbour, Vancouver Island	37 200 (37 200)	0.42 (0.45)	- (-)	- (-)	- (-)	1.82 (1.68)	0.27 (0.24)	13 757 175 (13 339 997)	213 773 (226 152)	22.94 (23.08)	49 068 (52 196)	10 (10)
Molybdenum grade of ore milled: 1980, 0.016% Mo; 1979, 0.015%.												
Western Mines Limited, Lynx and Myra mines, Buttle Lake	900 (900)	1.22 (1.32)	7.58 (8.45)	1.23 (1.37)	- (-)	124.11 (131.31)	2.74 (2.91)	278 244 (266 877)	10 195 (10 247)	26.88 (27.96)	3 210 (3 315)	10 (10)
Yukon Territory												
Hudson Bay Mining and Smelting Co., Limited, Whitehorse Copper Division, Little Chief mine, Whitehorse	2 300 (2 300)	1.53 (1.12)	- (-)	- (-)	- (-)	10.29 (7.20)	0.96 (0.69)	775 013 (829 221)	23 718 (17 187)	45.23 (44.54)	10 728 (7 936)	6 (6)

TABLE 3. (cont'd)

Company and Location	Mill or Mine Capacity (tonnes)	Grade of Ore Milled Copper (%)	Zinc (%)	Lead (%)	Nickel (%)	Silver (grams/tonne)	Gold (grams/tonne)	Ore Milled (tonnes)	Copper Concentrates Produced (tonnes)	Grade of Copper in Concentrate (%)	Contained Copper Produced[1] In All Concentrates (tonnes)	Destination of Copper Concentrate[2]
Northwest Territories												
Echo Bay Mines Ltd., Port Radium, Great Bear Lake	130 (135)	0.81 (0.74)	- (-)	- (-)	- (-)	1167.09 (1748.57)	0.11 (-)	36 076 (36 083)	.. (..)	.. (..)	261 (231)	.. (..)
Terra Mining and Exploration Limited, Camsell River, Great Bear Lake	140 (180)	0.90 (1.03)	- (-)	- (-)	- (-)	376.80 (421.7)	- (-)	27 011 (31 020)	.. (..)	.. (..)	211 (278)	.. (..)

Sources: Company responses to Energy, Mines and Resources questionnaires, company reports and technical press.

[1] Total copper in concentrates of all metals. [2] Destination of concentrates: (1) Canadian Copper Refiners Limited, Mines Gaspé Division; (2) Noranda Mines Limited; (3) Inco Limited, Sudbury. (4) Falconbridge Nickel, Sudbury. (5) Falconbridge Nickel, Norway. (6) Hudson Bay Mining and Smelting Co., Ltd. (7) Sherritt Gordon Mines Ltd. (8) Afton Mines Ltd. (9) United States. (10) Japan. (11) Germany. (12) Korea. (13) Unspecified, and other countries. [3] A small portion of this copper was from Inco's Manitoba ores. [4] Capacity limited by Ontario SO_2 emission regulations. [5] Included in copper concentrate production for Mattabi Mines Limited. [6] Included in the Inco copper production for Ontario.
- Nil; .. Not available; * Estimated.


COPPER IN CANADA, 1980
Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
LEGEND
● PRODUCERS
○ PROSPECTIVE PRODUCERS
△ PROMISING DEPOSITS and EXPLORATION PROJECTS
★ SMELTERS
▲ REFINERIES

PRODUCERS

(numbers correspond to those in map above)

1. ASARCO Incorporated (Buchans Unit)
2. Consolidated Rambler Mines Limited (Ming mine)
3. Brunswick Mining and Smelting Corporation Limited (Nos. 6 and 12 mines)
   Heath Steele Mines Limited
4. Noranda Mines Limited, Division Mines Gaspé (Copper Mountain and Needle Mountain mines)
5. Madeleine Mines Ltd.
8. Campbell Resources Inc. (Cedar Bay, Henderson and Merrill mines)
   Lemoine Mines Limited (Patino N.V.)
   Patino Mines (Quebec) Limited (Copper Rand and Portage mines)
9. Corporation Falconbridge Copper, Opemiska Division (Perry, Springer and Cooke mines)
11. Noranda Mines Limited, Mattagami Division (Mattagami, Orchan, Norita mines)
13. Corporation Falconbridge Copper, Lake Dufault Division (Millenbach and Corbet Mines)
    Louvem Mining Company Inc.
14. Falconbridge Nickel Mines Limited (East, Falconbridge, Lockerby, North Onaping, Strathcona mines)
    Inco Metals Company (Clarabelle, Coleman, Copper Cliff South, Creighton, Frood, Garson, Levack, Little Stobie, Stobie, McCreedy West)

16. Texasgulf Inc. (Kidd Creek mine)
Pamour Porcupine Mines, Limited (Schumacher, Ross mines)
17. Noranda Mines Limited, Geco Division
19. Inco Metals Company (Shebandowan mine)
20. Corporation Falconbridge Copper, Sturgeon Lake Joint Venture
Mattabi Mines Limited
Noranda Mines Limited, Lyon Lake mine
21. Union Minière Explorations and Mining Corporation Limited (Thierry mine)
22. Selco Inc. (South Bay mine)
23. Inco Metals Company (Pipe No. 2 and Thompson mines)
24. Hudson Bay Mining and Smelting Co., Limited (Anderson, Centennial, Chisel, Flin Flon, Ghost, Osborne, Stall, Westarm and White Lake mines)
25. Sherritt Gordon Mines Limited Fox and Ruttan mines
27. Brenda Mines Ltd.
28. Newmont Mines Limited (Ingerbelle mine)
29. Bethlehem Copper Corporation (Iona and Jersey mines)
Lornex Mining Corporation Ltd.
Craigmont Mines Limited
Afton Mines Ltd.
30. Western Mines Limited (Lynx, Myra mines)
31. Utah Mines Ltd. (Island Copper mine)
32. Gibraltar Mines Limited
34 Equity Silver Mines Limited
36. Noranda Mines Limited (Bell Copper, Granisle mines)
37. Falconbridge Nickel Mines Ltd. (Wesfrob mine)
38. Canada Wide Mines Ltd. (Granduc mine)
42. Hudson Bay Mining and Smelting Co., Ltd. (Whitehorse Copper Division)
45. Terra Mining and Exploration Limited
46. Echo Bay Mines Ltd.

PROSPECTIVE PRODUCERS[1]

8. Campbell Resources Inc. Grandroy and other mines)
Patino Mines (Quebec) Limited (Portage mine)
11. Noranda Mines Limited (Phelps Dodge Corporation)
12. Selco Inc. - Hudson's Bay Oil and Gas Company Limited (Selbaie mine)
13. Noranda Mines Limited (New Insco mine)
14. Falconbridge Nickel Mines Limited (Fraser, Lindsley, North mines)
Inco Metals Company (Clarabelle, Copper Cliff North, Crean Hill, Fecunis, Levack East, Totten mines)
20. Noranda Mines Limited ("F" Group mine)
23. Inco Metals Company (Birchtree, Pipe No. 1, Soab North, Soab South mines)
24. Hudson Bay Mining and Smelting Co., Limited (Rod, Spruce Point, Trout Lake mines)
28. Newmont Mines Limited (Copper Mountain mine)
29. Teck Corporation (Highmont mine)
33. Noranda Mines Limited (Goldstream mine)

OTHER PROMISING DEPOSITS AND EXPLORATION PROJECTS[2]

10. Selco Inc. and Muscocho Explorations Limited (Lessard option deposit)
13. Noranda Mines Limited (Magusi River deposit)
14. Falconbridge Nickel Mines Limited (Craig, Onex mines)
Inco Metals Company (Cryderman, Whistle mines)
15. New Quebec Raglan Mines Limited
16. Teck Corporation - Metallgesellschaft Canada Limited - Domik Exploration Limited (Montcalm Twp.)
18. Great Lakes Nickel Limited
24. Hudson Bay Mining and Smelting Co., Limited (Wim mine)
26. Copper Giant Mining Corporation Limited (Poison Mountain deposit)
28. 20th Century Energy Corporation (Gambier Island deposit)
29. Bethlehem Copper Corporation (J.A. and Maggie deposits)
Valley Copper Mines Limited - Bethlehem Copper Corporation (Lake zone deposit)
30. Catface Copper Mines Limited (Falconbridge Nickel Mines Limited) (Catface deposit)
36. Noranda Mines Limited (Morrison deposit)
39. Falconbridge Nickel Mines Limited (Sustut deposit)
Kennco Explorations, (Western) Limited (Huckleberry Mountain deposit)
40. Sumitomo Metal Mining Canada Ltd. - Esso Minerals Canada (Kutcho Creek deposit)

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[1] Only mines with announced production plans and mines placed on standby.

[2] A more complete inventory is available in the publication **Canadian Mineral Deposits Not Being Mined in 1980**, Energy, Mines and Resources Canada, Mineral Policy Sector Internal Report MRI 80/7.

41. Liard Copper Mines Ltd. (Schaft Creek deposit)
    Stikine Copper Limited
    Texasgulf Inc. (Red Group)
43. Asarco Exploration Company of Canada, Limited, Silver Standard Mines Limited, Canadian Superior Exploration Limited, Falconbridge Nickel Mines Limited, and United Keno Hill Mines Limited (Minto Copper deposit)
44. Shell Canada Limited (Coates Lake, Jay deposits)
47. Texasgulf Inc. (Izok Lake, Hood River deposits)
48. Kennarctic Explorations Limited (High Lake deposit)
49. Cominco Ltd. (Hackett River deposit)
50. St. Joseph Explorations Limited (Heninga Lake deposit)

SMELTERS

4. Canadian Copper Refiners Limited Mines Gaspé Division
13. Noranda Mines Limited
14. Falconbridge Nickel Mines Limited
    Inco Limited
24. Hudson Bay Mining and Smelting Co., Limited
29. Afton Mines Ltd.

REFINERIES

7. Canadian Copper Refiners Limited
14. Inco Limited

SMELTERS AND REFINERIES

Production of refined copper in Canada rose 27.2 per cent in 1980 (Table 1) while smelter production was 512 800 t compared with 408 900 t in 1979 (Table 6).

There is growing pressure from the public and from governments concerning SO_2 emissions from smelters, coal-fired generating stations, petroleum refineries and the like, which result in the formation of acid rain in the atmosphere. Of the six Canadian copper smelters, only Noranda's Horne and Hudson Bay Mining's Flin Flon smelters completely lack SO_2 containment. The equipment installed at Noranda's Gaspé smelter is not working to design, owing to malfunctioning of the acid plant and to faulty original design.

Inco's copper flash smelter uses oxygen, and the SO_2 produced is liquified and sold to industrial users. Falconbridge Nickel has recently completed a smelter modernization program that meets environmental standards by production of sulphuric acid. SO_2 from the Afton Mines Ltd. smelter is captured and neutralized to form gypsum, which is disposed of in the tailings pond.

It seems likely that SO_2 emission controls, requiring at least partial SO_2 containment, are likely to be imposed during the 1980s on Canadian base-metal smelters where containment is a practical alternative.

WORLD SUPPLY AND DEMAND

World mine production of copper fell 1.6 per cent in 1980 (Table 7) while refined production rose marginally (Table 8). Consumption of refined copper (from primary and secondary sources) fell by 3 per cent in 1980.

CHARACTERISTICS AND USES OF COPPER

Most uses of copper are dependent on the metal's high electrical conductivity, durability and the high temperatures it can withstand. About half the copper consumed is for electrical uses, such as electrical and telecommunications wire and cable and electric motors. Other major uses are in industrial machinery, heat exchangers, turbines and locomotives. Copper is used in the motor vehicle industry. Substantial quantities of the metal are used in building construction, primarily in plumbing and electrical wiring. The manufacture of brass and other copper alloys is a major consumer of copper, with scrap a common source of much of the copper required. Other significant uses for copper are copper chemicals, munitions, coinage, jewellery and numerous other applications.

STOCKS

Total world stocks of refined copper declined slightly in 1980. According to the World Bureau of Metal Statistics, total commercial

TABLE 4. PROSPECTIVE COPPER PRODUCERS, 1980

Company and Location	Mine or Mill Capacity tonnes/day and Ore Grade	Year Production Expected or Expansion Completed	Destination of Copper Concentrates	Remarks
New Brunswick				
Brunswick Mining and Smelting Corporation Limited, No. 12 mine, Bathurst	10 000 Cu 0.32% Zn 9.18% Pb 3.76% Ag 96.3 g/t	1981	Gaspé	Expanding No. 12 mine to 10 000 tpd from 6 400. Development includes new 8-m diameter shaft, a new underground crusher, expansion of mill capacity to 10 000 tpd from 8 500 tpd.
Quebec				
Noranda Mines Limited, New Insco mine, Noranda	330 Cu 2.6% Ag 0.6 g/t Au ..	1981	Noranda	Deposit was previously in process of being prepared for production but was placed on standby.
Noranda Mines Limited, Phelps Dodge option, La Gauchetière township	450 Cu 1.1% Zn 4.9%	1982	Noranda	Deposit acquired from Phelps Dodge Corporation of Canada, Limited. Development delayed in 1977, being developed for production at a cost of $6 million.
Selco Inc. (66 2/3%) - Hudson's Bay Oil and Gas Co. (33 1/3%), Selbaie Joint Venture, Detour Lake	1 500 Cu 3.6% Zn 0.5% Ag 35.0 g/t Au 1.1 g/t	1981	Noranda	B-zone being developed as an underground operation. Hudson's Bay Oil and Gas purchased one-third interest from Pickands Mather & Co. Future underground production from A-2 zone and open-pit production from the A-1 zone is possible.
Ontario				
Falconbridge Nickel Mines Limited, Fraser mine, Sudbury area	Cu .. Ni ..	1981	Falconbridge	Shaft completed to 1 600 m (between Strathcona and Fecunis mines). Project originally begun in 1970 but deferred twice before completion. Preproduction and capital expenditures $11,275,000.
Noranda Mines Limited, "F" Group mine, Sturgeon Lake area	.. Cu 0.98% Zn 8.10% Pb 0.49% Ag 62 g/t	1981	Noranda	Ore to be treated at the nearby Mattabi Mines Ltd. concentrator.

TABLE 4. (cont'd)

Company and Location	Mine or Mill Capacity tonnes/day and Ore Grade	Year Production Expected or Expansion Completed	Destination of Copper Concentrates	Remarks
Manitoba				
Hudson Bay Mining and Smelting Co., Limited, Rod mine, Snow Lake	450 Cu 5.38% Zn 2.28% Ag 13.7 Au 1.0	1983	Flin Flon	Orebody leased from Falconbridge Nickel Mines Limited and Stall Lake Mines Limited for a royalty of 7 per cent of the net realized value from the metals produced. Ore to be treated at the Snow Lake concentrator.
Spruce Point mine, Reed Lake	653 Cu 2.7% Zn 4.3% Ag 32.6 g/t Au 1.7 g/t	1982	Flin Flon	Construction of this $16.1 million mine continued during the year.
Trout Lake mine, Flin Flon	1 630 Cu 2.6% Zn 4.3% Ag 9.8 g/t Au 1.5 g/t	1982-1983	Flin Flon	Mine to be developed for production by Hudson Bay at an initial rate of 815 tpd in 1982, rising to 1 630 tpd in 1983 at a cost of $25 million.
British Columbia				
Newmont Mines Limited, Copper Mountain mine, Princeton	Cu 0.41	1980-1981	Japan	Open-pit mine being prepared for production at former Copper Mountain mine. Ore to be crushed and transported to existing concentrator across the Similkameen River canyon. Limited ore deliveries to the Ingerbelle mill began October 1980, utilizing the new crushing facilities on the Copper Mountain side and the conveyor. Full production scheduled for 3rd quarter 1981 when mining at Ingerbelle scheduled to be discontinued.

TABLE 4. (cont'd)

Company and Location	Mine or Mill Capacity tonnes/day and Ore Grade	Year Production Expected or Expansion Completed	Destination of Copper Concentrates	Remarks
British Columbia (cont'd)				
Lornex Mining Corporation Ltd., Highland Valley	68% capacity expansion of mining and milling rate	1981	Japan and custom concentrate market	Mine expansion expected to be completed in summer 1981 at a cost of $160 million. Expanded facilities will include a third slightly larger semi-autogenous mill line, 18 new 155 t trucks, 3 new 17 cubic metre shovels, an additional tailings line and related facilities and new housing at Logan Lake.
Noranda Mines Limited, Goldstream mine, 80 km north of Kamloops	.. Cu 3.6% Zn 2.6% Ag 20 g/t	1982	Noranda	Mine and concentrator to be developed at a cost of $62 million.
Teck Corporation, Highmont mine, Highland Valley	22 600 Cu 0.27% Mo 0.047%	1981	Marc Rich	This $150 million project nearly complete at year-end.
Western Mines Limited, Price mine, Buttle Lake, Vancouver Island	..	1981	Japan	Price mine, adjacent to Lynx and Myra mines being prepared for production in 1981. Shaft sinking for nearby H-W orebody to commence early in 1981. Drill-indicated reserves at Price and H-W orebodies total 4.8 million tonnes averaging 2.1% Cu, 4.9% Zn, 0.3% Pb, 34 g/t Ag and 2.4 g/t Au.

Source: Energy, Mines and Resources Canada.

.. Not available.

TABLE 5. CANADIAN COPPER AND COPPER-NICKEL SMELTERS, 1980

Company and Location	Product	Rated Annual Capacity (tonnes of ores and concentrates)	Ore and Concentrates Treated (tonnes)	Blister or Anode Copper Produced (tonnes)	Remarks
Afton Mines Ltd., Kamloops, B.C.	Blister copper	22 500 (tonnes of blister copper)	35 700	20 700	The smelter commenced commercial operation on May 1, 1978. The uniquely low-sulphur concentrate, consisting chiefly of native copper, is smelted in a top-blown rotary converter. SO_2 produced is neutralized with limestone.
Falconbridge Nickel Mines Limited, Falconbridge, Ont.	Copper-nickel matte	570 000	..	26 000^p	A smelter modernization program begun in 1975 was completed in 1978 at a cost of $79 million. Fluid bed roasters and electric furnaces replaced older smelting equipment. A 1 800 tpd sulphuric acid plant treats roaster gases. The second of two fluid bed roaster-electric furnace lines was put on line in January 1980. Matte from the smelter is refined in Norway.
Inco Metals Company (Inco Limited), Sudbury, Ontario	Blister copper, nickel, sulphide and nickel sinter for the company's refineries; nickel oxide sinter for market, soluble nickel oxide for market	3 630 000[1]	..	132 000[2]	Oxygen flash-smelting of copper concentrate; converters for production of blister copper. Roasters, reverberatory furnaces for smelting of nickel-copper concentrate, converters for production of nickel-copper Bessemer matte. Production of matte followed by matte treatment, flotation, separation of copper and nickel sulphides, then by sintering to make sintered-nickel products for refining and marketing. Electric furnace melting of copper sulphide and conversion to blister copper.

TABLE 5. (cont'd)

Company and Location	Product	Rated Annual Capacity (tonnes of ores and concentrates)	Ore and Concentrates Treated (tonnes)	Blister or Anode Copper Produced (tonnes)	Remarks
Noranda Mines Limited, Horne smelter, Noranda, Que.	Copper anodes	900 000	838 000, of which 672 000 were custom concentrates	205 000	Three reverberatory furnaces, one of which is now considered to be permanently shut down; 5 converters; 1 continuous reactor; an 85 tpd oxygen plant to supply oxygen-enriched blast. Continuous reactor modified to produce matte instead of metal. A $35 million project is under way to overhaul and modify the smelter, with electricity to become the plant's major energy source. A new 450 tpd oxygen plant will decrease unit fuel requirements and increase capacity of the continuous reactor, so another reverberatory furnace can be closed. Equipment expected to be operational first quarter 1983.
Noranda Mines Limited, Gaspé smelter, Murdochville, Que.	Copper anodes	325 000	266 000, of which 78 000 were custom concentrates	63 000	Equipped with one fluid bed roaster, one reverberatory furnace and two converters plus an acid plant. Fed with Gaspé and custom concentrates.
Hudson Bay Mining and Smelting Co., Limited, Flin Flon, Man.	Copper anodes	400 000		66 000, of which 36 000 were from custom concentrates or from Whitehorse Copper Division concentrates	Five roasting furnaces, one reverberatory furnace and three converters. Company treats its own copper concentrates from mines at Flin Flon, Snow Lake and Whitehorse, as well as custom copper concentrates and zinc plant residues and stockpiled residues fed to reverberatory furnace.

Source: Energy, Mines and Resources Canada.

[1] Includes copper and nickel-copper concentrates and iron ore recovery plant feed. This capacity cannot all be fully utilized owing to Ontario government sulphur dioxide emission regulations. [2] A small portion of this copper was from Inco's Manitoba ores.
[e] Estimated; .. Not available.

TABLE 6. COPPER REFINERIES IN CANADA, 1980

Company and Location	Rated Annual Capacity	Output in 1980	Remarks
	(tonnes)		
Noranda Mines Limited, CCR Division, Montreal East, Quebec	435 000	372 000	Refines anodes from Noranda's Horne and Gaspé smelters and from the Flin Flon smelter; also purchased scrap. Copper sulphate and nickel sulphate recovered by vacuum evaporation. Precious metals, selenium and tellurium recovered from slimes. Produces C.C.R. brand electrolytic copper wirebars, ingot bars, ingots, cathodes, cakes and billets.
Inco Metals Company (Inco Limited), Copper Refining Division, Copper Cliff, Ont.	180 000	132 000	Casts and refines anodes from molten converter copper from the Copper Cliff smelter; also refines purchased scrap. Gold, silver, selenium and tellurium recovered from anode slimes, along with platinum metals concentrates. Recovers and electrowins copper from Copper Cliff nickel refinery residue. Produces ORC brand electrolytic copper cathodes, and wirebars.

Source: Energy, Mines and Resources Canada.

stocks of refined copper, which were 1 087 700 t at the end of 1979, had fallen to 1 028 400 t by the end of 1980. London Metal Exchange stocks were 122 600 t at the end of 1980, compared with 126 500 t at the end of 1979. New York Commodity Exchange stocks were 162 900 t at the end of 1980, up from 97 900 t at the end of 1979.

NATIONAL STOCKPILES

The United States strategic stockpile goal for copper was 907 185 t, with holdings at the end of 1980 of 20 200 t, no change from those at the end of 1979. Sales from the Japanese copper stockpile during 1980 resulted in a decline in holdings from 36 900 t at the end of 1979 to 7 600 t at the end of 1980.

INTERNATIONAL DEVELOPMENTS

In the United States, Atlantic Richfield Company announced that its wholly-owned subsidiary, The Anaconda Company, was suspending operations indefinitely at its copper smelter at Anaconda, Montana (capacity 190 000 tpy of copper) and the nearby copper refinery at Great Falls, Montana (capacity 230 000 tpy of refined copper). The company said that the plants could not be economically retrofitted to satisfy environmental standards. The closings will affect 1,500 employees. Anaconda will continue to operate its Berkeley open-pit mine at Butte.

Copper production in Zaire and Zambia continued to be plagued by production, transport and other difficulties. Production in Zaire was 15 per cent higher than in 1979 but Zambian production was only slightly more than in 1979 and was still at depressed levels relative to earlier years. A threatened major strike in Zambia was avoided by renegotiation of the three-year contract.

In Mexico, the large La Caridad mine in Sonora, which had opened in May 1979, continued to experience technical and labour turnover problems, aggravated by a severe drought and resultant electricity cutbacks. Although the concentrator has occasionally operated at up to 70 000 tpd (some 4 000 t above its rated capacity), equipment problems and inadequately trained personnel have limited operations, on average, to about 45 per cent of rated capacity.

TABLE 7. WORLD MINE PRODUCTION OF COPPER, 1979 AND 1980

	1979	1980P
	(000 tonnes)	
United States	1 443.6	1 175.3
USSR	1 150.0	1 150.0
Chile	1 061.0	1 067.7
Canada	636.4	710.1
Zambia	588.3	595.8
Zaire	399.8	460.0
Peru	397.0	353.0
Poland	345.0	345.0
Philippine Republic	300.5	310.0
Australia	234.7	234.6
Republic of South Africa	203.2	214.7
Mexico	110.2	167.0
Papua New Guinea	170.8	146.8
Yugoslavia	96.0	123.0
Indonesia	57.2	56.6
Japan	59.1	53.2
Other communist countries	323.1	323.1
Other noncommunist countries	361.3	354.0
Total	7 937.2	7 839.9

Sources: World Bureau of Metal Statistics, April 1981, and Energy, Mines and Resources Canada.
P Preliminary.

TABLE 8. WORLD PRODUCTION OF REFINED COPPER, 1979 AND 1980

	1979	1980P
	(000 tonnes)	
United States	1 980.3	1 684.9
USSR	1 480.0	1 480.0
Japan	983.7	1 014.3
Chile	781.6	810.7
Zambia	563.6	607.3
Canada	397.3	505.2
Belgium	368.8	378.0
West Germany	382.5	374.0
Poland	335.8	350.0
Peru	230.8	231.0
Australia	173.8	183.0
United Kingdom	121.7	162.5
Spain	144.4	157.7
Republic of South Africa	152.3	152.9
Zaire	103.2	144.2
Yugoslavia	137.5	131.0
Mexico	100.4	102.9
Sweden	61.7	55.7
Other communist countries	500.5	501.0
Other noncommunist countries	359.2	376.5
Total	9 359.3	9 482.8

Sources: World Bureau of Metal Statistics, April 1981, and Energy, Mines and Resources Canada.
P Preliminary

In Iran, little if any further progress has been made in preparing the Sar Cheshmeh Copper Mining Co. mine for production.

In June, Texasgulf Inc. sold its 20 per cent interest in the large Empresa de Cobre Cerro Colorado copper deposit in Panama to Rio Tinto Zinc Corporation Limited (RTZ) for $US 5.5 million, which represented Texasgulf's expenditures on the project. Texasgulf retained an option to buy back a 15 per cent interest in the project after Rio Tinto completes a further feasibility study. If Texasgulf does not exercise the option, Rio Tinto is to pay Texasgulf another $US 1.9 million. Rio Tinto now has a 49 per cent interest in Empresa de Cobre Cerro Colorado the company which is to develop the orebody, with a Panamanian government agency holding the other 51 per cent. Earlier, Rio Tinto had purchased a 29 per cent interest from the Panamanian government. Rio Tinto is to conduct an eight-month feasibility study costing $10-12 million. Texasgulf had estimated that a copper price of between $US 1.50 and $2.00 would be necessary to yield an adequate return on investment for the Cerro Colorado project.

Peru plans to increase its copper output over the next 10 to 15 years from 397 000 t in 1979 to a forecast 800 000 t when projects under way are completed. Total investment required for the expansion is estimated at between $US 5 billion and $7 billion. The $300 million Tintaya copper property is to be developed, and a further $300 million is to be invested in second phase sulphide ore production at the Cerro Verde operation. The World Bank has loaned Peru $100 million to expand production at the Cobriza copper complex, operated by the state company Empresa Minera del Centro del Peru S.A. (CENTROMIN-PERU), from the present 16 000 tpy to 26 000 tpy of copper. Other deposits for which production is likely are Toro Mocho, Antamina, Michiquillay, stage two of Toquepala, and nearby Quellaveco. The Tintaya project should produce about 60 000 tpy of blister copper,

TABLE 9. WORLD CONSUMPTION OF REFINED COPPER, 1979 AND 1980

	1979	1980P
	(000 tonnes)	
United States	2 168.3	1 859.9
USSR	1 360.0	1 360.0
Japan	1 330.1	1 325.7
West Germany	794.1	759.2
United Kingdom	498.8	409.2
Italy	352.0	395.5
France	358.4	386.7
Belgium	303.1	318.0
Brazil	238.7	245.2
Canada	243.2	208.6
Poland	202.0	202.0
Yugoslavia	119.0	142.0
Australia	127.2	128.4
Spain	132.5	125.5
East Germany	122.0	122.0
Sweden	107.6	105.3
Other communist countries	607.1	607.0
Other noncommunist countries	746.3	834.7
Total	9 800.4	9 534.9

Sources: World Bureau of Metal Statistics, April 1981, and Energy, Mines and Resources Canada.
P Preliminary.

from a one per cent porphyry copper orebody. A new democratic Peruvian civilian government came into power in July, slashed import duties by an average of 50 per cent, and plans to phase out Peru's 17.5 per cent export tax on sales of mineral products.

In Papua New Guinea, copper production at the huge Bougainville copper mine continued to drop, owing to decreasing ore grades and lower than anticipated metallurgical recoveries. Copper grade has dropped from 0.75 per cent in 1972 to 0.47 per cent in 1980, so that metal production for the first six months of 1980 was 15.8 per cent below that for the same period in 1979, despite a slight increase in ore milled, to 18.8 million t from 18.3 million t. Profits remained steady, owing to higher prices for copper, gold and silver.

Also in Papua New Guinea, the government gave preliminary approval for the Ok Tedi copper-gold project in central New Guinea, near the border with West Irian. The mine is to be developed by a consortium of companies led by The Broken Hill Proprietary Company Limited of Australia. Reserves at Ok Tedi are over 400 million t, with a leached gold-bearing cap of 34 million t grading 2.86 g/t of gold, overlying 371 million t of porphyry ore averaging 0.7 per cent copper (with molybdenum and gold) and 25 million t of skarn ore averaging 1.17 per cent copper. If final company-government negotiations are successful, development should start in 1981, with mining of the gold rich cap of the deposit to commence in 1984 at an initial rate of about 12 000 tpd. Copper production should begin two years later.

Elsewhere in Papua New Guinea, the Frieda River copper prospect is generating considerable interest. A four-company consortium is exploring and evaluating the property. Work so far has indicated a porphyry copper zone of 500 million t averaging 0.52 per cent copper and 0.29 g/t gold in the Horse-Ivaal deposit and an additional 260 million t of 0.41 per cent copper and 0.23 g/t gold in the Koki deposit.

BP Australia Ltd., a subsidiary of The British Petroleum Company Limited, has agreed to bear all cost of a $A 50 million feasibility study on the Olympic Dam copper-uranium deposit in Australia, owned by Western Mining Corporation Limited. BP will also fund an expanded exploration program in the area, at a cost of between $10 million and $100 million. The deposit is estimated to have reserves of some 750 million t averaging about 1.5 per cent copper and 0.06 per cent U_3O_8.

Construction started on China's largest copper refinery, in the province of Jiangxi, to have an annual capacity of 90 000 t of copper. The refinery, part of the Jiangxi copper complex, is due to begin operation in 1982.

The Chilean Copper Commission expects Chile's copper production to increase by 90 per cent over the next 10 years, with investment over this period to total some $6.5 billion. Exxon Corporation is considering a tenfold expansion at its Disputa de las Condes mine at a cost of $US 1.2 billion to raise ore output in 1986 to about 80 000 tpd and copper output to some 250 000 tpy. The project will be one of the world's largest nonferrous mining projects. Further exploration at Anaconda Copper Company's Los Pelambres deposit, purchased in 1979, puts reserves for a portion of the deposit at 430 million t of 0.78 per cent copper and 0.03 per cent molybdenum. The potential is high for the deposit to reach production and the possible investment will exceed $1.5 billion. At the Quebrada Blanca deposit (owned by Superior Oil Company, Falconbridge Nickel Mines Limited, Canadian Superior Oil Ltd. and McIntyre Mines Limited), feasibility and engineering studies are under way to assess whether a $US 630 million operation, to produce 100 000 tpy of copper, can come on-stream by 1986.

Noranda Mines Limited announced that it would not proceed with development of its 51 per cent-owned Andacollo copper project in Chile, because it has been unable to arrange sufficiently attractive financing terms with the Canadian Export Development Corporation and a group of banks for the $452 million project. The Chilean government subsequently announced plans to seek international bids to develop the Andacollo deposit, and will repay Noranda the cost of preliminary work done on the project.

Labour Disputes

Some 40,000 workers in the U.S. copper industry walked off their jobs at midnight on June 30, when the unions and the companies were unable to agree on a new three-year contract, halting production at Kennecott Corporation, Phelps Dodge Corporation, Magma Copper Company, Cities Service Company, The Anaconda Company, ASARCO Incorporated, Inspiration Consolidated Copper Company and AMAX Inc. Workers also struck the Copper Range Company at midnight July 31. In total, some 85 per cent of U.S. copper production (about 15 per cent of world copper production) was idled by the strikes. By August, only two U.S. copperproducers, Duval Corporation and Cyprus Mines Corporation, remained in production.

Work resumed on Sept. 10 at operations of Kennecott Corporation, the first company to settle. The companies settled one by one until late in November when ASARCO and Anaconda, the last two companies to settle, resumed production. Only about half of the 2,500 Anaconda workers got their jobs back, owing to the permanent closure of the company's smelter and refinery in Montana in September.

U.S. mine copper production in 1980 was 1 168 300 t, compared with 1 443 600 t in 1979, with the decline mostly an outcome of the strike.

In Peru, 1,500 workers at the Cuajone copper mine of Southern Peru Copper Corporation went on strike on November 12 forcing the company to declare **force majeure** on its December copper shipments. The strike, which idled Cuajone's copper output of 180 000 t annually (almost half of Peru's total copper production), was settled December 11.

US FTC Consent Orders

Following acquisition of The Anaconda Company by the Atlantic Richfield Company (Arco) in 1976, the United States Federal Trade Commission (FTC) in 1979 issued consent orders listing companies excluded from eligibility to purchase certain Anaconda copper properties that Arco was required to divest under U.S. antitrust legislation. Following complaints by the listed U.S. copper producers, only those U.S. producers with more than 10 per cent of the country's copper market remained prohibited from purchasing the properties, along with Noranda Mines Limited, Inco Limited, and Anglo American Corporation of South Africa Ltd. (and its subsidiaries, including Hudson Bay Mining and Smelting Co., Limited).

A complaint was made by the Canadian government to the U.S. State Department late in 1979, and another was made by Noranda directly to the FTC. The matter was reopened by the FTC in 1980. In October, the FTC issued a modified consent order which put Noranda, Inco and the Anglo American group in the same position as U.S. producers having between 5 per cent and 10 per cent of the U.S. copper market, in that they must obtain FTC approval if they wish to be eligible to purchase any of the Anaconda deposits. None of the three holds as much as 5 per cent of the U.S. market, but the total copper production of each of the three companies is larger than 5 per cent of the U.S. copper market.

UNCTAD Copper Discussions

Only one United Nations Conference on Trade and Development (UNCTAD) copper meeting was held in 1980. This was the second session of the 7th Preparatory Meeting held in Geneva February 18-22. At the first session (September 24-28, 1979) the chairman had tabled a three-stage proposal designed as a compromise between those countries wishing to move immediately into negotiations for a full-fledged international

TABLE 10. WORLD COPPER PRODUCTION AND CONSUMPTION, 1980P

	Mine Production	Refined Production	Refined Consumption
		(000 tonnes)	
United States	1 175.3	1 684.9	1 859.9
USSR	1 150.0	1 480.0	1 360.0
Japan	53.2	1 014.3	1 325.7
CIPEC[1]	3 037.5	2 107.2	336.0
Europe	174.4	1 301.0	2 698.5
Canada	710.1	505.2	220.5
Other communist countries	668.1	851.0	921.0
Other noncommunist countries	871.3	459.2	801.4
Total	7 839.9	9 402.8	9 523.0

Sources: World Bureau of Metal Statistics, April 1981, and Energy, Mines and Resources Canada.

[1] Intergovernmental Council of Copper Exporting Countries includes: Australia, Chile, Indonesia, Mauritania, Papua New Guinea, Peru, Yugoslavia, Zaire and Zambia.
P Preliminary

copper agreement, and those advocating more caution and further technical work. The first session adjourned to study the proposals. At the resumed session in February 1980, there was no agreement on the chairman's proposal, because many nations found it unacceptable. The meeting was deadlocked and no acceptable compromise was found.

Canada has yet to be convinced that a copper agreement is either desirable or manageable at this time. The general Canadian position on international commodity agreements is that any agreement should include both producing and consuming nations.

On September 30, the Intergovernmental Committee for the Integrated Proposal for Commodities of UNCTAD instructed Secretary-General Gamani Corea to "hold consultations on the question of preparatory work on copper with the main consuming and producing countries, then decide on what further steps would be appropriate". This decision has temporarily shelved the question of reopening preparatory meetings.

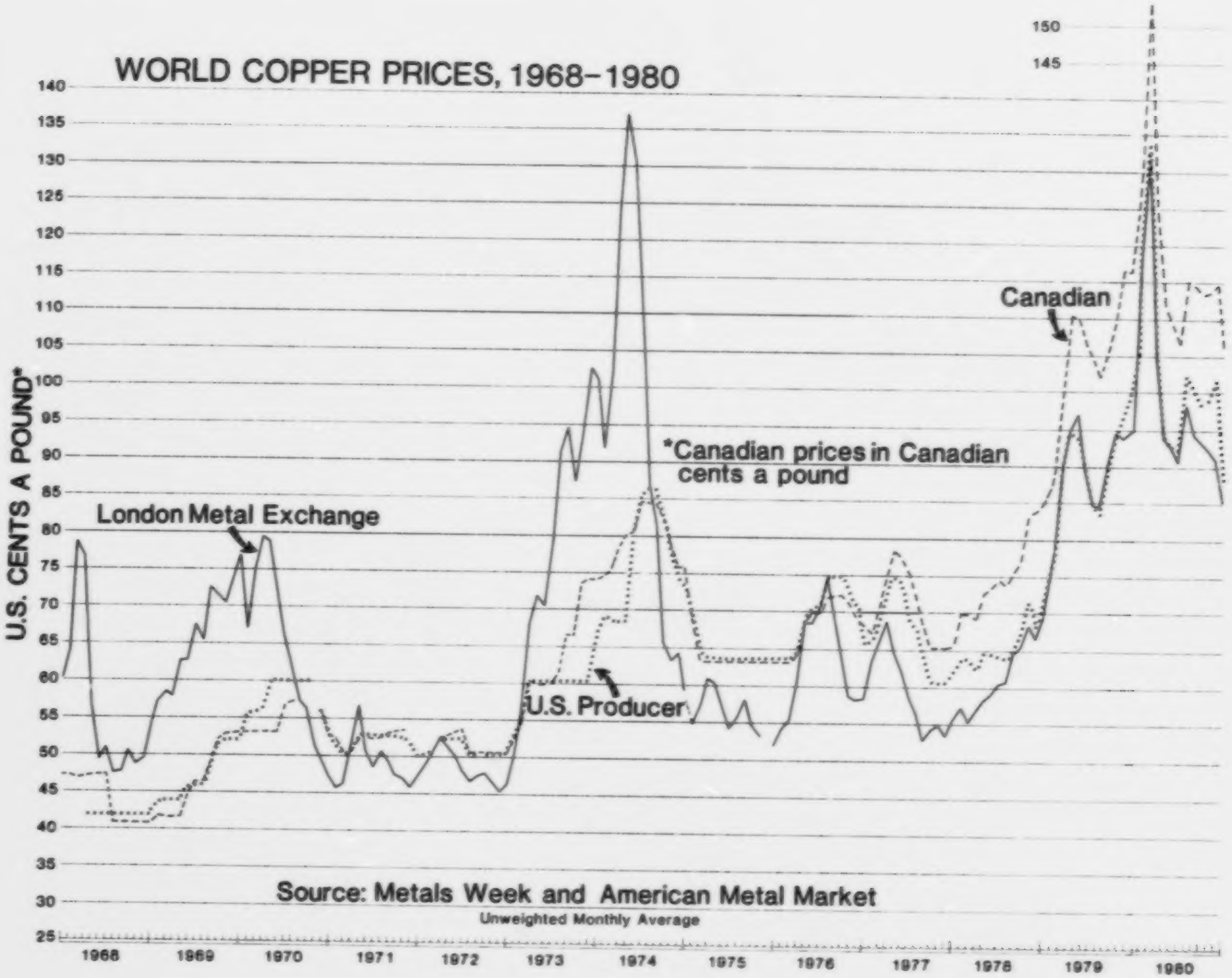
PRICES

Copper prices, which had risen together with gold, silver and platinum prices throughout the second half of 1979, rose sharply and peaked in mid-February at over $1.60 Canadian per pound. This price rise was largely speculative and related to speculative price levels for the precious metals. The copper price then dropped from February until early summer, with the Canadian price for wirebar peaking again at about $1.26 a pound in late July, then dropping somewhat again in August. The price then remained relatively stable, mostly in the $1.10 to $1.15 a pound range, until December, when it averaged $1.068 a pound. The average annual producer price for wirebar copper was $1.18, a pound including the premium of .625 cents a pound over the full plate cathode price. The U.S. and London Metal Exchange (LME) prices behaved similarly. The average LME cash price for wirebars was ¢US 99.25 a pound.

OUTLOOK

The settlement of the U.S. copper strike suggests a degree of stability in that country's copper supply picture for the next two and a half to three years. Although copper production from Zambia and Zaire is depressed relative to the past, production levels in those countries seem to be slowly increasing, although this trend may not continue. Significant increases in copper production over the 1980s seems likely from known deposits in Chile, Canada, Peru and other countries.

In the short term, a period of copper oversupply and lower copper prices seems probable until the current world economic



WORLD COPPER PRICES, 1968–1980

*Canadian prices in Canadian cents a pound

Source: Metals Week and American Metal Market

Unweighted Monthly Average

slump ends. On the positive side, world copper consumption should continue to grow over the longer term, at about 3 per cent a year. Some experts predict an even higher rate of growth in demand for copper during the 1980s. New copper mining projects already being developed, along with anticipated new copper discoveries, would appear to be capable of meeting demand during the 1980s, provided copper prices are adequate to bring on the needed new mines. However, copper supplies are still likely to be tight during periods of high demand.

In terms of 1980 Canadian dollars, average copper prices that have prevailed over the long term since the end of World War II are close to $1.40 a pound. The price of just over $Cdn 1.00 a pound at the end of 1980 will not be sufficient to ensure adequate supplies of copper to the world, so that copper prices are almost certain to rise once the current world economic recession ends.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
32900-1	Copper in ores and concentrates	free	free	free	free
33503-1	Copper oxides	free	14.7	25.0	free
34800-1	Copper scrap, matte and blister and copper in pigs, blocks or ingots; cathode plates of electrolytic copper for melting, per lb	free	free	1.5¢	free
34820-1	Copper in bars or rods, for manufacture of trolley, telegraph, telephone wires, electric wires and cables	free	4.9	10.0	free
34835-1	Electrolytic copper powder (expires June 30, 1981)	free	free	10.0	free
34845-1	Electrolytic copper wire bars, per lb (expires June 30, 1981)	free	free	1.5¢	free
35800-1	Anodes of copper	free	free	10.0	free

MFN Reductions under GATT (effective January 1 of year given)

Item No.	1980	1981	1982	1983	1984	1985	1986	1987
					(%)			
33503-1	14.7	14.4	14.1	13.8	13.4	13.1	12.8	12.5
34820-1	4.9	4.8	4.6	4.5	4.4	4.3	4.1	4.0

UNITED STATES (MFN)		1980	1981	1982	1983	1984	1985	1986	1987
						(%)			
Item No.									
602.30	Copper, ores etc.	Remains free							
612.02	Unwrought copper etc.	1.7			- no change -				1.7
612.08	Copper waste and scrap	5.6	5.1	4.7	4.2	3.8	3.3	2.9	2.4

TARIFFS (cont'd)

EUROPEAN ECONOMIC COMMUNITY (MFN)		1980	Base Rate	Concession Rate
Item No.				
26.01	Copper, ores and conc.	free	free	free
74.01	Copper in matte etc.	free	free	free

JAPAN (MFN)

Item No.		1980	Base Rate	Concession Rate
26.01	Copper, ores and conc.	free	free	free
74.01	(1) Copper in matte etc.	free	free	free
	(2) Copper, unwrought			
	(a) containing not more than 99.8% by weight of copper etc.	8.2%	8.5%	7.3%
	(b) Other			
	(i) Containing by weight, not less than 25% of zinc and not less than 1% of lead.	21.75yen/kg	24yen/kg	15yen/kg
	(ii) Containing more than 95% by weight of copper			
	- blister copper in bar	8.2%	8.5%	7.3%
	- other	23.25yen/kg	24yen/kg	21yen/kg
	(iii) Containing not more than 95% by weight of copper	23.25yen/kg	24yen/kg	21yen/kg
	(3) Waste and scrap			
	(a) Unalloyed	1.9%	2.5%	free
	(b) Other: containing more than 10% by weight of nickel	16.9%	22.5%	free
	(c) Other	1.9%	2.5%	free

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue, Canada; Tariff Schedules of the United States Annotated (1980), USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 22, No. L342, 1979; Customs Tariff Schedules of Japan, 1979; GATT Documents, 1979.

Crude Oil and Natural Gas

R.L. THOMAS

During 1980, the remaining established reserves of crude oil and natural gas liquids in Canada continued to decline as production of total liquid hydrocarbons exceeded new additions to reserves. The net production of crude oil declined by 6 per cent over 1979 while the net production of liquids increased by some 21 per cent, resulting in an overall decrease of almost 1 per cent from 1979. The output of synthetic crude oil increased by 35 per cent from the two existing oil sands plants.

The established remaining reserves of marketable natural gas decreased slightly as production was higher than the gross additions. During the year, the net withdrawals of gas increased by 8 per cent over the 1979 level.

Total revenues from the sales of crude oil, liquids, natural gas, and sulphur amounted to $16,473 million compared to $13,169 million received in 1979, for an increase of 25 per cent. A breakdown, in millions of dollars, is as follows: crude oil and condensate - $8,976; natural gas - $5,573; natural gas liquids - $1,490; and sulphur - $435.

Net cash expenditures of the petroleum industry increased by 28 per cent to $15,768 million. Of the total expenditures, royalties accounted for some 31 per cent; exploration costs, 34 per cent; and development costs, 21 per cent. Land costs account for 54 per cent of the exploration costs and most of the land costs can be attributed to the "bidding" system used toward purchasing the right to explore for and develop the oil and natural gas resources. While western Canada, including North of 60°, accounted for 88 per cent of the total expenditures, the industry spent some 71 per cent in Alberta, the major producing province.

At the close of 1980, the Canadian drilling industry had established a record for well completions in Canada during a year. Almost 9,200 wells were drilled compared to 7,701 in 1979 for an increase of 19 per cent. An actual total of 9,188 oil, gas and dry wells were drilled to an aggregate depth of 10.5 million metres (m), an increase of 1.8 million m over the 8.7 million m drilled in 1979. The number of successful oil and gas completions increased by two points, over 1979, to 78 per cent with the number of successful exploratory oil and gas wells increasing by 686 to 2,517 completions.

Crude oil refining capacity decreased somewhat during 1980 to a level of 362 000 cubic metres per day (m^3/d) from 375 000 m^3/d in 1979. Although operating at the same capacity, 83 per cent as in 1979, the receipts had decreased to approximately 301 000 m^3/d. This fall, Gulf Canada Limited terminated operations at its Point Tupper installation, located in Nova Scotia, due to a reduction in demand. Meanwhile, Petro-Canada had submitted an offer to purchase the idle refinery at Come-by-Chance in Newfoundland. The purchase was completed in 1981, but the facility remains inoperative pending a series of studies necessary to bring the plant back on-stream.

Concerning the further development of Canada's oil sands, the Alsands Project Group continued to experience delays in construction of its facility. The plant is designed to produce 22 200 m^3/d of synthetic crude oil and the capital cost has now escalated to some $12 billion. A joint effort at the planning stage is that by Canstar Oil Sands Ltd. proposed by PetroCanada and Nova, an Alberta Corporation which will be similar in size and cost to the Alsands plant. The two existing oil sands plants, Syncrude Canada Ltd. and Suncor Inc., had a combined average production of 20 000 m^3/d during the year and this amount was well below their rated capacities. In the Cold Lake region, Esso Resources Canada Limited was still waiting for approval to commence construction of its heavy oil upgrading facility.

OUTLOOK

The outlook for Canadian natural gas continues to be much more promising than crude oil as future gas supply exceeds demand. The federal government has introduced a number of oil conservation schemes designed to encourage Canadians to substitue their oil usage to other forms of energy. One of these incentives, the Canadian Oil Substitution Program (COSP) encourages homeowners to convert their homes from furnace oil to any other energy source: natural gas, electricity, solar, etc. The automobile industry has introduced the use of propane, a byproduct of natural gas, as a source of fuel. Large fleet owners, such as taxi companies and couriers, are encouraged to switch to this fuel because of abundant supply. It is anticipated that western natural gas will soon be flowing into Quebec and the Maritimes as an alternate fuel to crude oil.

Canada's conventional oil reserves in southern basins have been steadily declining for the past decade, but recent major oil discoveries in the frontier regions, off the east coast and in the Beaufort Sea are expected to offset the production decline when put on-stream. Also, improved oil recovery for pools in Alberta and Saskatchewan will contribute an additional 160 million m^3 of oil to established reserves within the next decade.

RESERVES

According to the 1980 Reserves Report of the Canadian Petroleum Association, Canada's remaining reserves of liquid hydrocarbons (crude oil and natural gas liquids) declined by 134.7 million m^3 to 1 154 million m^3, comprised of 951.2 million m^3 of crude oil, 92.8 million m^3 of pentanes plus and 110.3 million m^3 of other liquids (propane, butane and ethane). Total production during the year amounted to some 87.6 million m^3, or an average of 240 000 m^3/d, resulting in a reserves-life index of 13.2 years should production remain constant.

Alberta, containing more than 83 per cent of Canada's total oil and being the largest producer, recorded a net decline in reserves of 139 million m^3. The gross additions were revised downward considerably, that is, some of the pools containing oil were actually smaller than originally calculated.

The remaining established reserves of marketable natural gas declined slightly by 4 193 million m^3 to a year-end level of 2 492 billion m^3. Although overall reserves increased in western Canada, this amount was more than offset by a major downward revision that occurred in the far north.

PRODUCTION

Average net production of crude oil, including synthetic and natural gas liquids totalled some 281 162 m^3/d in 1980, a decrease of 10 822 m^3/d from 1979. Crude oil and condensate production decreased from a 1979 daily output of 221 921 m^3/d to 206 879 m^3/d or a decline of 7 per cent. The production of natural gas liquids - propane, butane, pentanes plus, and ethane - decreased marginally by 1 416 m^3/d to 52 458 m^3/d with only ethane showing a slight increase. The combined output of synthetic crude oil from the Syncrude and Suncor plants averaged 21 825 m^3/d during the year, an increase of 35 per cent over 1979; Syncrude's average production was 13 000 m^3/d and Suncor was able to produce almost 9 000 m^3/d.

Alberta continues to account for 88 per cent of Canada's liquid hydrocarbon production. A decline of 4 per cent was recorded in total production with crude oil and condensate registering a 4.4 per cent

TABLE 1. CANADA, RESERVES OF LIQUID HYDROCARBONS AT END OF 1980

	Crude Oil	Pentanes Plus	Propane, Butane and Ethane	Total	Per cent of Total
			(000 cubic metres)		
Northern Canada	21 009	13 229	1 960	36 198	3.1
Alberta	779 980	76 848	104 911	961 739	83.3
Saskatchewan	117 752	305	1 007	119 064	10.3
British Columbia	25 898	2 431	2 455	30 784	2.7
Eastern Canada	6 589	-	-	6 589	0.6
Total	951 228	92 813	110 333	1 154 374	100.0

Source: Canadian Petroleum Association.
- Nil.

decline. Saskatchewan's production of all liquids decreased by almost 1 per cent and British Columbia output declined by 8 per cent.

The net withdrawals of natural gas amounted to 87 109 million m^3, or 239 million m^3/d which was some 20 million m^3 less than in 1979. Alberta continued to be the largest producing province followed by British Columbia with the balance coming from Saskatchewan, Ontario and the Northwest Territories.

Not all of the natural gas produced from a well is delivered to market. Some of this gas requires processing in order to remove any liquids and sulphur that may be present, and then reinjected into the well so that reservoir pressure can be maintained. Sometimes the reinjected gas is part of the distributor's storage operations. Various volumes are stored by gas utilities during low-demand periods, usually in the summer, and later withdrawn as required to meet peak demand in the winter. This process also assists in levelling out the utilities' demand on the trunk carriers over the year. In Alberta and Ontario, most of the gas is stored in former-producing fields that have been depleted. However, in Saskatchewan much of the storage is in large man-made subsurface caverns that have been leached from salt beds specifically to provide storage facilities near major-consuming areas.

TABLE 2. CANADA, ESTIMATED YEAR-END MARKETABLE RESERVES OF NATURAL GAS, 1979 AND 1980

	1979	1980
	(million cubic metres)	
Alberta	1 646 392	1 661 442
British Columbia	207 363	208 694
Saskatchewan	35 431	33 651
Eastern Canada	8 918	8 301
Northern Canada	597 953	579 776
Total	2 496 057	2 491 864

Source: Canadian Petroleum Association.

ACTIVITY

At year-end 1980, the Canadian drilling industry had achieved a record high for well completions by drilling 9,188 oil, gas and dry wells to an aggregate depth of some 10.5 million metres. A total of 7,138 wells were successful producers - 2,805 were oil and 4,333 were gas. Western Canada, being the centre of activity, accounted for 8,932 well completions and a total depth of almost 10.4 million metres. In Manitoba, six of the wells not included in Table 7 were classified as potash wells. Well completions for 1980, compared to 1979, in Canada increased by 19 per cent and metrage increased by some 21

TABLE 3. PRODUCTION OF LIQUID HYDROCARBONS BY PROVINCE, 1979 AND 1980

	1979^r		1980P	
	(000 m^3)	(m^3/day)	(000 m^3)	(m^3/day)
Alberta				
Crude	74 392[1]	203 814	71 159[2]	194 956
Condensate	137	375	114	312
Propane	5 542	15 184	5 260	14 411
Butane	3 472	9 512	3 245	8 890
Pentanes plus	6 472	17 732	5 891	16 140
Ethane	3 660	10 027	4 334	11 874
Total	93 675	256 644	90 003	246 584
Saskatchewan				
Crude	9 372	25 677	9 331	25 564
Condensate	19	52	17	47
Propane	76	208	67	184
Butane	36	99	31	85
Pentanes plus	24	66	21	58
Total	9 527	26 101	9 467	25 937
British Columbia				
Crude	2 140	5 863	2 002	5 485
Condensate	32	88	37	101
Propane	85	233	76	208
Butane	113	310	90	247
Pentanes plus	184	504	134	367
Total	2 554	6 997	2 339	6 408
Canada				
Crude	86 722[1]	237 595	83 309[2]	228 244
Condensate	188	515	168	460
Propane	5 702	15 622	5 402	14 800
Butane	3 621	9 921	3 366	9 222
Pentanes plus	6 681	18 304	6 045	16 562
Ethane	3 660	10 027	4 334	11 874
Total	106 574	291 984	102 624	281 162

Source: Statistics Canada.

[1] Synthetic equals 5 909.4. [2] Synthetic equals 7 966.3.
P Preliminary; ^{r} Revised

per cent. Alberta, responsible for 77 per cent of drilling activity in Canada, showed an increase in completions of 22 per cent with much of the increase resulting from higher exploratory drilling.

Exploration in the frontier regions has been more successful than in conventional areas due to discoveries of large oil and gas deposits. In the shallow waters of the Beaufort Sea, Esso Resources Canada Limited constructed an artificial island in order to drill its Issungnak 0-61 well which flowed 382 m^3/d of 35° API oil on test. Esso had drilled other wells in the productive zone and plans to continue this program to fully evaluate all zones. Elsewhere in the Beaufort Sea, Dome Petroleum Limited continued its multi-well program. The Tarsiut A-25 tested flow rates of 127 m^3/d of oil and 90 000 m^3/d of gas. Dome continued to further evaluate an earlier discovery of oil

TABLE 4. CANADA, LIQUIDS AND SULPHUR RECOVERED FROM NATURAL GAS, 1969-80

	Propane	Butane	Condensate Pentanes Plus	Sulphur
	(cubic metres)	(cubic metres)	(cubic metres)	(tonnes)
1969	2 831 090	1 778 223	6 126 421	3 773 919
1970	3 382 352	2 099 228	7 019 513	4 309 041
1971	3 851 547	2 455 929	7 456 208	4 628 393
1972	4 696 619	3 093 703	9 671 111	6 723 409
1973	5 315 544	3 567 161	9 867 029	7 115 881
1974	5 268 092	3 519 638	9 413 046	6 950 327
1975	5 531 963	3 642 717	8 816 323	6 487 466
1976	5 410 000	3 583 000	7 872 000	6 422 000
1977	5 512 000	3 650 000	7 712 000	6 500 040
1978	5 205 100	3 355 900	6 926 300	6 310 511
1979r	5 702 400	3 621 000	6 869 200	6 281 500
1980p	5 402 200	3 365 900	6 212 800	6 182 500

Source: Statistics Canada.

r Revised; p Preliminary.

at Kopanoar. It is anticipated that through successful stepout wells to be drilled during the 1981 season, this field could be on-stream by 1985.

Panarctic Oils Ltd., continuing its program of exploration in the Arctic Islands, completed three ice island wells during the year. The Whitefish H-63A well has a step-out of the H-63 gas discovery made in 1979. The Balaena D-58 was classified as an abandoned oil well and the Char G-07 was a gas discovery. Panarctic drilled the Wallis K-62 dry test for Dome, although Panarctic holds no interest in this well. Panarctic expects to drill three new wells in the 1980-81 season.

The oil and gas discovery of Hibernia, offshore from Newfoundland, continues to remain in the spotlight as each new well better defines the complex geological structure. Indications are that the field has an oil productive capacity of 32 000 m^3/d. Recent test rates of 3 000 m^3/d of oil have been achieved and these and other flow rates have led industry and governments to believe the reservoir could contain more than 160 million m^3 of oil in place. Of the 11 tests conducted at the recent Hibernia B-08 well, nine of these had flow rates for oil ranging between 202 m^3/d and 909 m^3/d and gas flow rates between 57 000 m^3/d and 525 000 m^3/d. The partners in this operation are: Mobil Oil Canada, Ltd.

TABLE 5. OIL AND GAS WELLS IN WESTERN CANADA AT END OF 1980

	Wells Capable of Production		Wells Actual Producing	
	Oil	Gas	Oil	Gas
Alberta	18,833	19,546	13,312	16,661
Saskatchewan	10,107	839	8,320	719
Manitoba	823	NIL	720	NIL
British Columbia	905	1,801	588	604
Northwest Territories and Arctic Islands	59	9	37	7
Total	30,727	22,195	22,977	17,991

Sources: Provincial and federal government reports.

TABLE 6. WELLS DRILLED BY PROVINCE, 1979 AND 1980

	Oil		Gas		Dry[1]		Total	
	1979	1980	1979	1980	1979	1980	1979	1980
Western Canada								
Alberta	1,256	1,639	3,216	3,968	1,263	1,388	5,735	6,995
Saskatchewan	956	1,099	45	49	232	295	1,233	1,443
British Columbia	80	31	187	219	128	134	395	384
Manitoba	16	18	-	-	9	9	25	27
Yukon and Northwest Territories and Arctic Islands	2	4	2	5	17	7	21	16
Westcoast offshore	-	-	-	-	-	-	-	-
Sub-total	2,310	2,791	3,450	4,241	1,649	1,833	7,409	8,865
Eastern Canada								
Ontario	6	12	83	91	120	122	209	225
Quebec	-	-	-	-	7	3	7	3
Atlantic provinces	-	-	-	-	3	-	3	-
Eastcoast offshore	1	2	1	1	4	6	6	9
Hudson Bay offshore	-	-	-	-	-	-	-	-
Sub-total	7	14	84	92	134	131	225	237
Total Canada	2,317	2,805	3,534	4,333	1,783	1,964	7,634	9,102

Source: Canadian Petroleum Association.
[1] Includes suspended and abandoned wells, but excludes miscellaneous and service wells.
- Nil.

(operator), Gulf Canada Resources Inc., Chevron Standard Limited, Petro-Canada, and Columbia Gas Development of Canada Ltd. Should production plans be approved in the near future, oil flow rates of 8 000 m^3/d could be reached by 1985 and 32 000 m^3/d might be achieved by 1990.

A number of oil and gas discoveries were made in western Canada during the year. The Cutbank oil play in Alberta, continues to record successful oil wells, but as yet no reserve estimates have been given. Late in the year, Hudson's Bay Oil and Gas Company Limited announced seven oil strikes in the Pine Creek region of west-central Alberta, and each of these wells had been able to flow rates of almost 70 m^3/d. Texaco Canada Resources Ltd. had a wildcat discovery in the West Pembina area which flowed some 380 m^3/d of oil. The foothills region of western Alberta continues to be a major centre of exploration activity because of the successful discoveries of natural gas. It is expected that sizeable additions to gas reserves, which would be surplus to domestic requirements, may permit increased exports of the gas.

In oil sands projects, the Alsands Project Group has announced possible delays in its operations because of lack of provincial approvals in the context of federal-provincial disagreements on pricing. Also, the Esso Resources Canada Limited heavy oil facility at Cold Lake requested a $40 million operating loan, which was granted by the federal government. Esso has promised to continue its operations for an additional six months in order that a pricing agreement can be reached.

TRANSPORTATION

Construction of oil and gas pipelines in Canada increased somewhat in all categories, which includes gathering, transmission and distribution lines. A great portion of activity occurred in Alberta with much of the attention concentrated on the pre-build portion of the Alaska Highway natural gas pipeline. Upon completion of this system, some 68 million m^3/d of gas is expected to flow from Prudhoe Bay through Canada and into the United States. Natural gas from the Mackenzie Delta, via the Dempster line, will

TABLE 7. CANADA, WELLS COMPLETED AND METRES DRILLED, 1979 AND 1980

	1979		1980	
	(No.)	(metres)	(No.)	(metres)
Western Canada				
British Columbia				
New field wildcats	31	72 652	75	164 559
Other exploratory	153	272 947	160	292 051
	184	345 599	235	456 610
Development	211	339 571	151	238 175
Total	395	685 170	386	694 785
Alberta				
New field wildcats	213	417 811	155	334 950
Other exploratory	1,880	2 828 645	2,444	3 649 302
	2,093	3 246 456	2,599	3 984 252
Development	3,660	3 606 040	4,445	4 413 681
Total	5,753	6 852 496	7,044	8 397 933
Saskatchewan				
New field wildcats	203	161 474	347	291 870
Other exploratory	396	305 150	541	466 042
	599	466 624	888	757 912
Development	659	501 181	570	461 480
Total	1,258	967 805	1,458	1 219 392
Manitoba				
New field wildcats	9	8 805	12	11 619
Other exploratory	-	-	-	-
	9	8 805	12	11 619
Development	16	11 732	15	11 890
Total	25	20 537	27	23 509
Yukon and Northwest Territories and Arctic Islands				
New field wildcats	16	43 785	10	23 836
Other exploratory	-	-	-	-
	16	43 785	10	23 836
Development	11	11 151	7	13 274
Total	27	54 936	17	37 110
Total western Canada				
New field wildcats	472	704 527	599	826 834
Other exploratory	2,429	3 406 742	3,145	4 407 395
	2,901	4 111 269	3,744	5 234 229
Development	4,557	4 469 675	5,188	5 138 500
Total	7,458	8 580 944	8,932	10 372 729
Eastern Canada				
Eastcoast offshore				
New field wildcats	6	27 239	7	23 420
Other exploratory	-	-	-	-
	6	27 239	7	23 420
Development	-	-	2	9 224
Total	6	27 239	9	32 644
Ontario				
New field wildcats	38	26 782	19	11 474
Other exploratory	31	18 947	84	48 838
	69	45 729	103	60 312
Development	152	76 042	135	64 442
Total	221	121 771	238	124 754

TABLE 7 (Cont'd.)

	1979		1980	
	(No.)	(metres)	(No.)	(metres)
Quebec				
New field wildcats	7	12 641	3	8 253
Other exploratory	-	-	-	-
	7	12 641	3	8 253
Development	-	-	-	-
Total	7	12 641	3	8 253
Atlantic provinces				
New field wildcats	3	1 539	-	-
Other exploratory	-	-	-	-
	3	1 539		
Development	-	-	-	-
Total	3	1 539	-	-
Total eastern Canada				
New field wildcats	54	68 201	29	43 147
Other exploratory	31	18 947	84	48 838
	85	87 148	113	91 985
Development	152	76 042	137	73 666
Total	237	163 190	250	165 651
Total Canada				
New field wildcats	526	772 728	628	869 981
Other exploratory	2,460	3 425 689	3,229	4 456 233
	2,986	4 198 417	3,857	5 326 214
Development	4,709	4 545 717	5,325	5 212 166
Total	7,695	8 744 134	9,182	10 538 380

Source: Canadian Petroleum Association.
- Nil.

be connected into the major line for use in southern Canadian markets. The complete system, including processing facilities, is expected to cost around $30 billion with the Canadian portion costing an estimated $3.5 billion.

Shipments of liquified natural gas from the high Arctic are expected to commence in 1986. The Arctic Pilot Project proposes to transport 7 million m^3/d of natural gas by way of tankers, from Melville Island to a port either in Quebec or the Maritimes. The estimated cost of the project exceeds $2 billion.

Trans Quebec & Maritimes Pipeline Inc. (TQM) intend to build a gas pipeline from Montreal to Cape Breton Island by 1985. The cost of this 1 400 kilometre (km) system is estimated to be over $1 billion.

TABLE 8. LENGTH OF PIPELINES IN CANADA FOR TRANSPORTING CRUDE OIL NATURAL GAS LIQUIDS AND PRODUCTS, 1963-80

Year-end	Kilometres[1]	Year-end	Kilometres[1]
1963	17 070	1972	29 467
1964	18 900	1973	30 146
1965	19 819	1974	31 262
1966	20 913	1975	31 831
1967	22 780	1976	32 863
1968	23 870	1977	33 463
1969	27 480	1978	34 421
1970	27 459	1979	34 868
1971	28 706	1980	35 663

Source: Statistics Canada

[1] Includes producer gathering lines from 1969 to 1980.

TABLE 9. KILOMETRES OF EXISTING GAS PIPELINES IN CANADA, 1975-80

	1975	1976	1977	1978	1979r	1980
Gathering						
New Brunswick	9.7	20.8	20.8	20.8	20.8	20.8
Quebec	1.6	2.1	-	-	-	-
Ontario	1 839.5	1 992.0	1 939.1	1 946.2	2 062.9	2 105.2
Saskatchewan	1 643.1	2 290.1	2 757.2	1 813.4	1 899.7	1 871.5
Alberta	10 050.4	12 848.4	13 822.3	13 816.2	14 355.0	16 077.8
British Columbia	1 907.1	2 069.8	2 120.3	2 590.6	2 708.3	3 084.3
Northwest Territories and Yukon	54.7	55.0	55.0	55.0	55.0	55.0
Total	15 506.1	19 278.2	20 715.2	20 242.2	21 101.7	23 214.6
Transmission						
New Brunswick	20.9	21.6	21.6	21.6	21.6	21.6
Quebec	238.2	237.7	265.0	256.4	256.3	256.4
Ontario	9 224.8	9 387.8	9 345.9	9 242.6	9 314.6	9 441.1
Manitoba	2 743.9	2 743.4	2 779.0	2 778.9	2 806.7	2 675.0
Saskatchewan	10 581.4	10 614.9	10 862.5	10 702.8	10 666.9	10 765.4
Alberta	13 930.5	15 596.0	17 075.4	17 739.5	18 000.0	18 120.6
British Columbia	5 042.1	5 087.5	5 177.1	5 249.3	5 230.6	5 283.3
Total	41 781.8	43 688.9	45 526.5	45 991.1	46 296.5	46 563.6
Distribution						
New Brunswick	51.5	146.1	146.1	146.1	146.1	146.1
Quebec	2 975.7	2 890.0	2 938.9	2 972.1	2 999.4	3 028.9
Ontario	28 033.2	28 715.7	29 378.8	29 444.1	30 478.4	31 836.9
Manitoba	2 655.4	2 738.8	2 815.1	2 876.1	2 976.7	3 049.4
Saskatchewan	4 789.4	4 966.3	5 078.8	5 287.8	5 421.2	5 592.1
Alberta	18 851.9	21 554.1	25 065.1	26 850.2	28 950.8	31 092.1
British Columbia	9 285.9	9 397.6	9 789.3	10 072.1	10 188.5	10 766.6
Total	66 643.0	70 409.5	75 212.1	77 648.5	81 161.1	85 512.3
Total Canada	123 930.9	133 376.6	141 453.8	143 881.8	148 559.3	155 290.5

Source: Statistics Canada.

r Revised; - Nil.

An oil pipeline extending from Norman Wells, Northwest Territories to Zama, Alberta is being considered, and waiting for federal approval, by Interprovincial Pipe Line (NW) Ltd. This 866 km pipeline would send 4.5 thousand m^3/d of crude from the Norman Wells area. Construction of the system is expected to commence in 1983, be completed in 1985, and the anticipated cost would be some $360 million.

MARKETS AND TRADE

The production of crude oil, natural gas liquids and synthetic crude oil averaged 281 162 m^3/d, almost 4 per cent less than in 1979. Imports of crude oil and products averaged 95 200 m^3/d, or 7 per cent less than last year so that Canada's total supply averaged 376 427 m^3/d.

TABLE 10. CONSUMPTION OF PETROLEUM PRODUCTS BY PROVINCE, 1980

	Motor Gasoline	Kerosene, Stove Oil, Tractor Fuel	Diesel Fuel Oil	Light Fuel Oil No. 2 and 3	Heavy Fuel Oil No. 4, 5 and 6
	(000 cubic metres)				
Atlantic provinces	3 262	331	1 454	2 299	4 897
Quebec	8 687	411	2 757	5 241	5 854
Ontario	13 317	256	3 338	4 894	2 826
Manitoba	1 610	116	768	161	128
Saskatchewan	2 059	154	1 085	193	20
Alberta	5 044	80	2 943	111	14
British Columbia	4 409	131	2 501	787	1 357
Northwest Territories and Yukon	87	59	220	87	22
Total	38 475	1 538	15 066	13 773	15 118

Source: Statistics Canada.

Canadian refineries received 109.8 million m^3 of crude oil during this year, a decrease of 2.9 million m^3 over the previous year, as a result of a decline in imported crude from the Middle East and Venezuela. Canadian refineries are operating at approximately 79 per cent of their capacity, processing some 300 000 m^3/d.

By year-end, the domestic demand for crude and products averaged 300 000 m^3/d, a 1 per cent decline over 1979. Exports of petroleum to the United States also declined by 9 per cent to an average of 76 866 m^3/d.

Net withdrawals of natural gas decreased by 8 per cent to 238 million m^3/d from 258 million m^3/d in 1979. Domestic sales decreased only slightly to 118 million m^3/d with the largest reduction occurring in volumes for export.

During the year the domestic price of natural gas at the Toronto city gate was increased from $2.15 per million British thermal units (btus) in January to $2.30 in February; to $2.60 in September, and in November a tax of $0.30 was added. The export price of natural gas was increased from $US 3.45 in January to $4.47 in February and remained constant.

In January the domestic price of Canadian crude at the wellhead was, $92.82/$m^3$ and in August this was increased to $105.41/$m^3$. The export price of crude in

TABLE 11. CANADA, EXPORTS AND IMPORTS OF REFINED PETROLEUM PRODUCTS, 1979 AND 1980

	Exports		Imports	
	1980	1979	1980	1979
	(000 cubic metres)			
Propane and butane	357	99	-	1
Aviation gasoline	-	-	-	-
Motor gasoline	672	825	176	79
Aviation turbo fuel	150	184	62	-
Kerosene, stove oil and tractor fuel	36	8	2	-
Diesel fuel oil	19	316	84	141
Light fuel oil No. 2 & No. 3	1 973	1 785	13	23
Heavy fuel oil No. 4, 5 & 6	2 699	2 788	1 111	704
Asphalt	77	89	14	18
Petroleum coke	-	-	757	619
Lubricating oils & greases	22	11	101	128
Other products	1 597	497	149	144
Total, all products	7 602	6 602	2 580	1 857

Source: Statistics Canada.
- Nil.

TABLE 12. CANADA, CRUDE OIL PRODUCTION, TRADE AND REFINERY RECEIPTS, 1968-80

				Refinery Receipts[1]		
	Production	Imports	Exports	Domestic	Imports	Total
				(000 cubic metres)		
1968	60 319	28 258	26 628	37 549	28 187	65 736
1969	65 342	30 704	31 375	38 480	30 284	68 764
1970	73 322	33 011	38 299	41 172	33 123	74 295
1971	78 339	38 947	43 049	41 852	38 829	80 681
1972	89 347	44 781	54 255	43 441	45 908	89 349
1973	104 272	52 057	66 784	47 716	49 491	97 207
1974	97 742	46 290	53 015	55 250	47 582	102 832
1975	82 802	47 416	41 727	50 963	47 777	98 740
1976	76 075	43 930	29 030	56 455	41 871	98 326
1977	76 447	39 593	19 783	65 420	38 819	104 239
1978	76 001	36 821	15 578	68 055	35 691	103 746
1979	86 722	35 430	16 761	77 240	35 419	112 659
1980	83 309	32 230	11 939	77 572	32 230	109 802

Source: Statistics Canada.

[1] Includes condensate and pentanes plus.

TABLE 13. CANADA, CRUDE OIL RECEIVED AT REFINERIES, 1979 AND 1980

		Country of Origin					
Location of Refineries		Canada	Middle East	Venezuela	Africa	Other	Total Received
				(000 cubic metres)			
Atlantic provinces	1979	-	12 196	5 906	249	306	18 657
	1980	61	11 182	4 053	152	700	16 148
Quebec	1979	15 764	3 513	6 355	751	3 105	29 488
	1980	16 571	3 896	5 578	321	3 010	29 376
Ontario	1979	31 848	-	-	-	2 904	34 752
	1980	31 212	-	-	-	3 273	34 485
Prairies	1979	19 846	-	-	-	134	19 980
	1980	20 030	-	-	-	66	20 096
British Columbia	1979	9 639	-	-	-	-	9 639
	1980	9 548	-	-	-	-	9 548
Northwest Territories and Yukon	1979	144	-	-	-	-	144
	1980	158	-	-	-	-	158
Total	1979	77 241	15 709	12 261	1 000	6 449	112 660
	1980	77 580	15 078	9 631	473	7 049	109 811

Source: Statistics Canada.
- Nil.

January was \$138.55/m^3 and progressively increased each month until in December the price became \$180.80/m^3.

In October of 1980, the Canadian government introduced a new budget and the National Energy Program, a document designed to stimulate activity and growth of the Canadian petroleum industry in the producing provinces and in the frontiers. Soon after, however, it became clear to analysts in government and industry that a definite downturn in activity would occur in 1981. Natural gas was in an over-supply situation compared to existing domestic and export markets, the industry had built up an excess capacity of services and equipment, and the price for Canadian crude oil was far below the international level.

TABLE 14. CANADA, SUPPLY AND DEMAND OF OILS, 1979 AND 1980

	1979	1980
	(000 cubic metres)	
Supply		
Production		
Light-medium	68 985	64 109
Heavy	12 045	11 700
Synthetic	5 475	7 415
Pentanes plus	6 935	6 243
Natural gas liquids	9 125	13 177
Total production	102 565	102 644
Imports		
Crude oil	35 405	32 231
Products	1 825	2 516
Total imports	37 230	34 747
Total supply	139 795	137 396
Demand		
Domestic	110 230	109 320
Exports		
Light-medium	9 490	6 731
Heavy	6 570	5 211
Pentanes plus	730	-
Products	6 602	7 288
Natural gas liquids	7 300	8 826
Total exports	30 692	28 056
Stock changes	730	-2 483
Uses and losses	-1 127	-2 463
Total demand	139 795	137 396

Source: Energy, Mines and Resources Canada.

TABLE 15. CANADA, SUPPLY AND DEMAND OF NATURAL GAS, 1980 AND 1979

	1980	1979
	(million cubic metres)	
Supply		
Gross new production	100 571	107 042
Field waste and flared	-1 664	-1 568
Reinjected	-11 798	-11 048
Net withdrawals	87 109	94 426
Processing shrinkage	12 155	12 706
Net new supply	74 954	81 720
Removed from storage	4 835	3 964
Placed in storage	-4 441	-4 659
Net storage	394	-695
Total net domestic supply	75 348	81 025
Imports	3	2
Total supply	75 351	81 027
Demand		
Domestic sales		
Residential	9 624	9 614
Industrial	23 519	24 628
Commercial	10 120	9 264
Total	43 263	43 506
Field and pipeline use in production	6 390	6 523
Pipeline	2 042	2 440
Other	2 258	1 601
Adjustment metering differences	-1 271	-148
Line pack changes	17	103
Total field and pipeline use	9 436	10 519
Gas unaccounted for	89	-1 342
Total domestic demand	52 788	53 042
Exports	22 563	28 344
Total demand	75 351	81 027

Source: Statistics Canada.

Fluorspar

B.W. BOYD

Fluorspar, or fluorite in mineralogical nonmenclature, is calcium fluoride (CaF_2), an industrial mineral with a broad spectrum of uses. The most important of these are: for the manufacture of hydrofluoric acid and other fluorine chemicals; as a fluxing agent in various metallurgical processes, the most important being steel manufacture; for the manufacture of artificial cryolite, an essential cell ingredient in the electrolytic reduction of alumina to aluminum; in the refining of uranium ores; and in the glass and ceramic industries.

During the 1960s, world fluorspar consumption grew rapidly because of increasing demands in the steel, aluminum and chemical industries. Due to a combination of technical, economic and environmental developments, consumption stagnated during the 1970s. Greater use of the basic oxygen process in steelmaking, which requires about three times more fluorspar, as a slag thinner, than the more traditional basic open-hearth process, should influence demand for fluorspar in this sector. However, slack demand in the steel industry over the last three years has tempered growth of metallurgical-grade fluorspar consumption. Recent concern about concentrations of fluorocarbons in the upper atmosphere led to legislation by the United States and Canadian governments banning nonessential uses of these chemicals. Aerosol spray products are alleged to be the main offenders.

PRODUCTION IN CANADA

Fluorspar is the principal source of the element fluorine. It occurs in many geological environments from low-temperature fracture fillings to high-temperature emplacements and, as a result, it is not restricted to any particular geological province in Canada. In fact, fluorspar is known to occur in all physiographic provinces, with the exception of the interior plains.

Domestic production of fluorspar ceased when Alcan Smelters and Chemicals Limited closed its mine at St. Lawrence in Newfoundland in 1977. Concentrates from St. Lawrence were shipped to Alcan's aluminum smelter at Arvida, Quebec. Total production from the district was more than 6 million t of ore. The fluorspar veins on Burin Peninsula are genetically related to two large stocks of alaskite (granitic intrusive). Most of this favourable area is obscured by shallow overburden, but innumerable showings and float blocks containing fluorspar are known.

Allied Chemical Canada, Ltd., imports acid-grade fluorspar for the production of hydrofluoric acid at Valleyfield, Quebec and Amherstburg, Ontario. Some of the acid is utilized in the manufacture of various fluorine chemicals. Allied Chemical operates mines in Mexico and the United States to ensure an uninterrupted supply of fluorspar.

TABLE 1. CANADA, FLUORSPAR PRODUCTION, TRADE AND CONSUMPTION, 1979 AND 1980

	1979		1980P	
	(tonnes)	($000)	(tonnes)	($000)
Production (shipments)	-	-	-	-
Imports				
Mexico	105 862	10 444	108 962	14 090
Morocco	13 417	1 541	39 808	5 926
United Kingdom	-	-	21 311	3 585
South Africa	21 006	1 821	27 507	3 284
United States	19 203	2 045	17 752	1 493
Spain	-	-	8 599	1 489
Other countries	8 416	898	-	-
Total	167 904	16 749	223 939	29 867

	1978	1979
	(tonnes)	
Consumption[1] (available data)		
Metallurgical flux	30 880	31 281
Foundries	15 657	11 722
Other[2]	81 743	64 001
Total	128 280	107 004

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] As reported by consumers; breakdown by Energy, Mines and Resources Canada. [2] Includes consumption in the production of aluminum, chemicals, petroleum refining and other miscellaneous uses.
P Preliminary; - Nil.

International Mogul Mines Limited's barite-fluorite deposits east of Lake Ainslie, Cape Breton Island, Nova Scotia contain indicated reserves of 2.7 million t, grading 28 per cent barite and 19 per cent fluorite. Pilot plant testing, with the objective of producing an acid-grade concentrate at an acceptable rate of recovery, has yet to prove successful. From 1940 to 1949, approximately 1 300 t of fluorspar, along with some barite, were recovered from this deposit.

Prior to World War I, small tonnages of fluorspar were mined from vein-type deposits in the Madoc district of Ontario. As a strategic material of great importance, it showed a marked increase in production during the war. After the war, production decreased substantially, but was stimulated once again during World War II by government assistance for exploratory drilling programs and by loans on capital equipment. Fluorspar was mined continuously in the Madoc area up to 1961, when it became uneconomic.

The Rock Candy property, near Grand Forks, British Columbia, was mined intermittently from 1918 to 1942. Substantial reserves probably remain.

Fluorine is recovered as fluosilicic acid from the processing of phosphate rock by Erco Industries Limited, at Port Maitland, Ontario, and by Cominco Ltd., at Trail, British Columbia

Drilling at the Eaglet Mines Limited property near Quesnel Lake, British Columbia, has indicated an area of disseminated fluorspar large enough to encourage more investigation.

Other fluorspar occurrences of interest include the Liard River deposits in British Columbia, explored a few years ago by Jorex Limited and Conwest Exploration Company Limited; and Consolidated Rexspar Minerals & Chemicals Limited's large uranium-bearing, medium-grade fluorspar deposit adjacent to the Canadian National Railway line at Birch Island, about 95 km north of Kamloops.

USES, MARKETS AND TRADE

Fluorspar is marketed in three grades according to end-use: acid grade, containing a minimum of 97 per cent CaF_2; metallurgical grade, containing 60 to 80 per cent CaF_2; and ceramic grade, containing 88 to 97 per cent CaF_2.

Acid grade. Roughly 50 per cent of the world's fluorspar requirement is for acid grade used in the manufacture of hydrofluoric acid. Most of this material is beneficiated by flotation to achieve the high CaF_2 content required. In general, 2 to 3 t of ore must be mined to produce 1 t of acid-grade fluorspar concentrate, and the production of 1 t of hydrofluoric acid requires 2 t of acid-grade concentrate and almost 3 t of sulphuric acid. Hydrofluoric acid, produced according to the reaction:

$$CaF_2 + H_2SO_4 \rightarrow CaSO_4 + 2HF$$

has a variety of uses, but by far the most important is in the aluminum and chemical industries, which together account for some 80 per cent of consumption.

About one quarter of all hydrofluoric acid produced is used by the aluminum industry. Hydrofluoric acid is reacted with a sodium salt and aluminum fluoride to produce artificial cryolite, an essential cell ingredient for fluxing in the electrolytic reduction of alumina to aluminum. In recent years, fluorspar requirements have declined from 65 kilograms (kg) to 25 kg per t of aluminum produced as a result of increased cell efficiencies and recycling. Because fluorite is an essential raw material, many primary aluminum producers operate, or participate in the operation of, fluorspar mines to ensure uninterrupted and adequate supplies.

Almost 40 per cent of hydrofluoric acid is consumed in the manufacture of fluorocarbons. Fluorocarbons, which are used in the manufacture of solvents, resins, plastics, films, refrigerants and aerosol propellants, are produced by reacting hydrofluoric acid with carbon tetrachloride, or with chloroform. Fluorocarbons (more specifically, chloro-fluorocarbons) are currently under study as potentially harmful atmospheric pollutants. It is alleged that these substances react with the ozone layer in the upper atmosphere which filters out much of the sun's ultraviolet energy. The resulting increase in ultraviolet radiation could increase the incidence of skin cancer.

TABLE 2. WORLD FLUORSPAR PRODUCTION, 1978-80

	1978	1979	1980^e
		(tonnes)	
Mexico	959 783	875 000	816 000
U.S.S.R.	509 838	522 000	522 000
South Africa	393 275	454 000	454 000
People's Republic of China	399 000	399 000	408 000
Spain	397 535	408 000	408 000
Mongolia	454 862	408 000	408 000
France	314 793	318 000	318 000
Italy	171 216	176 000	191 000
United Kingdom	188 967	183 000	181 000
Thailand	230 531	181 000	163 000
Kenya	106 564	100 000	100 000
United States	117 415	99 000	78 000
Other countries	548 221	667 000	680 000
Total	4 792 000	4 790 000	4 727 000

Sources: U.S. Bureau of Mines, Mineral Commodity Summaries, 1981; U.S. Bureau of Mines Preprint 1978-1979.
^{e} Estimated.

Fluorspar is used in uranium refining. Uranium dioxide is reacted with anhydrous hydrofluoric acid to form a green salt (UF_4), which is then reacted with elemental fluorine in the form of fluorine gas to form UF_6, the feedstock for plants requiring enriched uranium. For each t of uranium processed into uranium hexafluoride, 1.66 t of fluorspar are required. This use will depend on the pace of developments in nuclear energy.

Metallurgical grade. Normally, about half of the world's fluorspar output is consumed as a metallurgical fluxing agent (metspar), primarily in the manufacture of steel. Metallurgical-grade fluorspar is used in the steel industry to remove impurities during melting and also to improve separation of metal and slag in the furnace by increasing the fluidity of the slag. Consumption of fluorspar in the steel industry has, over the years, increased substantially because of changing technology. Many steelmakers have shifted from the basic open-hearth process to the basic oxygen process. The latter consumes from 5 to 8 kg of metallurgical- grade fluorspar for each t of steel produced, compared with 1.5 to 2.5 kg in the open-hearth process. The electric furnace process consumes from 4 to 5 kg of metallurgical grade material for each t of steel produced. Within the next decade, older basic open-hearth furnaces will probably be replaced by more efficient new basic oxygen or electric furnaces. No satisfactory total substitute for fluorspar as a fluxing agent in steelmaking has been found, although research in this area is considerable. Indications are that the growth of metallurgical-grade reserves is not keeping pace with requirements. Consequently, steelmakers may have to switch more and more to higher-grade, higher-cost material, produced as flotation concentrates and converted into pellet or briquette form. Metallurgical-grade fluorspar is also used as a flux in foundries and in the reduction of dolomite to magnesium.

Ceramic grade. Ceramic-grade fluorspar is used as an opacifier in enamels and opal glass. It is also used to a limited extent in the manufacture of clear glass as an active flux, as a contributor to the gloss and as a decolourizer. Much of this grade of fluorspar concentrates can be used for the manufacture of hydrofluoric acid, or as pellets and briquettes for steelmaking. This latter application has been used during shortages of metallurgical-grade fluorspar.

CANADIAN CONSUMPTION AND TRADE

In 1980, fluorspar imports increased by 33 per cent to a record level. Mexico's share of our imports dropped to less than 50 per cent as consumers sought to diversify their sources of supply. Imports from Morocco, the United Kingdom and South Africa increased.

Prior to 1957, much of Canadian production was exported to the United States and Europe. In 1958, this trade was displaced by the development of low-cost deposits in Mexico by large consumers in the United States.

WORLD REVIEW

Expectation of a serious world shortage of fluorspar by 1970 resulted in intensive exploration efforts during the late 1960s and several new facilities were brought onstream. However, coincident with the surge in production came a slackening in demand due to an economic slowdown, most notably in the United States and Japan. World production, at 4.7 million t, is little changed from that of the previous ten years.

Mexico continued to rank as the world's largest supplier, producing some 17 per cent of total output, in 1980. Fluorspar mining began in Mexico prior to World War I. However, the industry received its greatest stimulus during World War II, when the United States government, cut off from European sources, encouraged exploration and development in Mexico. Most production is mined in the State of San Luis Potosi in the Zaragoza area, where two major producing mines are located within 1.5 km of each other. The Las Cuevas mine, which is the largest, accounts for over 30 per cent of total Mexican output and is the principal producer of metallurgical-grade fluorspar. In 1980, mill capacity at Las Cuevas was increased to 200 000 tpy acid grade fluorspar and 175 000 tpy metallurgical-grade. This underground operation is an affiliate of Noranda Mines Limited. The rapid growth of fluorspar production in Mexico over the years has paralleled consumption increases in the United States, which relies upon Mexico for most of its import requirements. Stagnation of production over the last few years reflects a levelling off in United States demand.

Quimica Fluor SA de CV's hydrofluoric acid plant at Matamoros started up in 1975.

It is one of four originally proposed in 1971.

The Mexican Fluorspar Institute, a producer organization, was formed in 1974. This body, supported by the government, formulates policy on sales and prices.

The United States is the world's largest consumer and is heavily reliant on imports to meet demand. In 1980, United States production was down to the lowest level since 1938. Part of the drop was due to temporary closure of Minerva Mines in Illinois but a trend to lower production overall has paralleled a decline in consumption over the past four years. Output of fluosilicic acid from 11 phosphate fertilizer plants was equivalent to 58 000 t of fluorspar. Imports for the year (including CaF_2 equivalent of hydrofluoric acid) totalled 816 000 t, 51 per cent of which were from Mexico. Most output in the United States comes from the Illinois-Kentucky district and is produced by two companies, Ozark-Mahoning Company (majority interest purchased by Pennwalt Corporation during 1975), and Inverness Mining Co., which through acquisition, took over the Minerva Mines.

Other states producing fluorspar intermittently are: Montana, Colorado, Idaho, Arizona, New Mexico and Utah.

OUTLOOK

The performance of the fluorspar industry necessarily parallels development in the steel, chemical and aluminum industries, which together account for 95 per cent of fluorspar consumption.

A combination of recessionary demand, economies in fluorspar use and environmental constraints resulted in a nine year, no-growth period in fluorspar consumption up to 1980. Large producer inventories and declining prices resulted in mine closures and deferred development plans.

Consumption of fluorspar in the aluminum industry appears to have reached a plateau as requirements per t of metal produced have declined. A new aluminum production technology, which reportedly reduces consumption of electricity by about 30 per cent and uses chlorine instead of fluorine, is in the development stage. Assuming adoption of the new technology, fluorspar in aluminum manufacture could disappear by the turn of the century. In the medium-term, however, some growth in fluorspar consumption in the aluminum industry is likely to result from the healthy growth in demand for this metal.

Many uncertainties surround the outlook for fluorspar consumption in steelmaking. Demand growth for steel products is tied to performance of the world economy which currently offers little hope for a fast recovery. There seems little doubt, that growth over the next few years will be modest. Nevertheless, any significant increase in steel demand will call forth even greater fluorspar usage to facilitate shorter residence time in the furnaces. Also, conversion to basic oxygen technology will continue, further increasing fluorspar demand. In addition to flux needs, about 160 000 t of acid grade equivalent is consumed as acid in pickling stainless steel.

Consumption in fluorocarbon manufacture has been the dominant force in fluorspar usage in the chemical industry in recent years. However, "nonessential" fluorocarbon products, principally aerosol sprays, were banned in Canada in April 1980 (amended to be more inclusive in May 1981), following the lead of the United States. The reduction in fluorspar consumption resulting from the ban has not been significant. Uranium enrichment and oil refining (alkylation) are strong growth segments that will moderate decline in the chemical sector. World consumption of fluorspar (acid grade) for these and other miscellaneous uses presently accounts for only 2.5 per cent of total fluorspar use, but growth rates in excess of 10 per cent per year over the long term seem likely.

In the longer term, the chemical industry would seem to offer the greatest scope for growth in fluorspar consumption. Fluorine, the most electronegative of elements, reacts with almost all organic and inorganic substances and, in view of this property, only the surface of its potential as a chemical has been scratched.

PRICES

United States fluorspar prices, quoted in **Engineering and Mining Journal** of January 1980. (net ton fob Illinois and Kentucky, CaF_2 content, bulk)

	($)
Ceramic, calcite and silica variable, CaF_2	
88-90%	100
95-96%	109
97%	121.50
In 100-lb paper bags, extra	10
Metallurgical pellets, 70% effective CaF_2	91
Acid, dry basis, 97% CaF_2	
Carloads	117
Bags, extra	9-10
Pellets, 88% effective	111
Wet filter cake, 8-10% moisture, sold dry content - subtract approximately	6
European and South African wet filter cake, 8-10% moisture, sold dry content, duty paid short ton cif East Coast, Great Lakes and Gulf ports, term contracts	130-145
Mexican	
Metallurgical, 70% effective CaF_2	
Mexican border, fob cars	66.70
Tampico, fob vessel	69.45
Acid, 97% + CaF_2 wet filter cake, bulk, fob Mexican border	84.14

fob Free on board; cif Cost, insurance and freight.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
29600-1	Fluorspar	free	free	free	free

M.F.N. Reductions under GATT (effective January 1 of year given)

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
29600-1	Fluorspar	Remains free							

UNITED STATES

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
						(%)			
522.24	Fluorspar, containing not over 97% calcium fluoride	13.5	13.5	13.5	13.5	13.5	13.5	13.5	13.5

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada. Tariff Schedules of the United States Annotated 1980, USITC Publication 1011. U.S. Federal Register Vol. 44, No. 241.

Gold

S.A. HAMILTON

Canada's gold mining industry, encouraged by large increases in the price of gold, experienced strong growth in exploration and new mine developments in 1980 that has been unmatched for many years. Former and existing gold producing areas enjoyed a major resurgence in exploration activity and new areas are being tested for economical deposits. Several properties reached the development stage during the year and additional production decisions are expected over the next few years if gold prices remain favourable. Nevertheless, most new producers will be relatively small and growth in Canada's gold production will be slow.

CANADIAN PRODUCTION

Gold production in Canada was 50 620 kilograms (kg) valued at $1.165 billion in 1980, compared with 51 142 kg valued at $591 million in 1979. The average yearly afternoon fixing price of gold on the London Gold Market in Canadian dollars for 1979 and 1980, was $11.05 per g, ($359.29 per ounce) and $23.02 per g, ($716.09 per oz.), respectively. The volume of production in 1980 was one per cent lower than the previous year but value increased by 49.3 per cent, owing to a sharp rise in the gold price. Byproduct gold production reported from base-metal ores was 4.9 per cent greater than in 1979. This may reflect an insistence by base metal producers on smelter contracts that pay for most or all of the precious metals recovered. Despite the opening of new lode gold mines, lode gold output was 8 per cent lower because higher gold prices enabled mine operators to treat lower grade ores and because some production was lost when one mine was shut down for some months by a strike, while another was closed temporarily by a cave-in. Record Canadian gold production was 166 254 kg (5,345,179 oz) achieved in 1941.

In 1980 lode gold mines in Canada accounted for 64.3 per cent of the country's gold output compared with 66 per cent in 1979. At the end of 1980 there were 29 lode gold mines in Canada operated by 22 companies. Substantial amounts of gold were recovered from placer deposits in the Yukon Territory and in British Columbia. Ontario continued to be the major gold producing province in Canada, and accounted for 38 per cent of the national total. Quebec, which reported a substantial increase in production in 1980 over 1979 due to the opening of a number of new gold mines, was next with 34 per cent. British Columbia was third with 15 per cent and the Northwest Territories fourth with 6 per cent.

Six new gold mines commenced production during the year, and a number of development decisions were announced that should see new mines producing in 1981 or 1982. No gold mines closed, although several operated on a salvage basis, their continued existence dependent on the high gold price being maintained. The established gold mining companies reported record breaking revenues and profits for 1980. Base-metal producers with significant precious metals recoveries also benefitted from high gold and silver prices that helped offset weaker base-metal prices.

TABLE 1. CANADA, PRODUCTION OF GOLD, 1979 AND 1980

	1979	1980
	(Kilograms)	
Newfoundland	395	234
New Brunswick	251	129
Quebec	14 722	15 548
Ontario	19 173	18 384
Manitoba	1 361	1 591
Saskatchewan	375	360
Alberta	42	133
British Columbia	8 277	7 447
Yukon	1 190	2 555
Northwest Territories	5 356	4 209
Total	51 142	50 620

Source: Energy, Mines and Resources Canada.

Costs per unit of gold produced continued to increase in 1980, as companies mined lower grade ore and as production costs, particularly labour, continued to increase.

CANADIAN DEVELOPMENTS

Atlantic Provinces. All gold produced in the Atlantic provinces in 1980 was derived as a byproduct of base-metal ores. The Buchans mine of ASARCO Incorporated, which was expected to close in 1979, continues to operate on a salvage basis. Exploratory work continues on various gold prospects in Nova Scotia, but none has as yet proved up sufficient reserves to justify a production decision.

Quebec. Campbell Resources Inc. commenced production at the Gwillim gold mine in April 1980. The first gold brick was poured in June. A separate gold circuit set up in the existing copper mill treats the Gwillim ore. Campbell is sinking an internal shaft in its Henderson copper mine to provide access to a recently discovered gold-copper orebody.

In June, Kiena Gold Mines Limited (controlled by Falconbridge Nickel Mines Limited) announced that its Dubuisson Township property would be brought into production at a cost of $25 million. A 403.5 m shaft had been sunk in 1965 but the price of gold at that time did not justify further development. Construction of surface facilities on the property was well advanced and by year-end a custom milling contract was signed with Teck Corporation's Lamaque unit to handle 816 500 tpy of ore for three years. Production is scheduled for October 1981. Reserves above a depth of 380 m are estimated at 3.29 million t averaging 6.27g/t gold.

The Doyon Mine, a joint venture of Société québécoise d'exploration minière (SOQUEM) and Silverstack Mines Ltd., a member of the Little Long Lac Minerals Group, began producing from an open-pit in March. 700 tpd is shipped to Noranda Mines Limited's Horne smelter where it is used as a flux, while 500 tpd is treated by the conventional cyanide process at Les Mines Est-Malartic Ltée custom mill. SOQUEM, the Quebec government mineral exploration and development company, is also involved in a joint venture with Muscocho Explorations Limited in a preproduction study of the Montauban gold deposit in Portneuf County.

Quebec Sturgeon River Mines Limited incorporated a subsidiary, Bachelor Lake Gold Mines Inc., to bring the Bachelor Lake property into production at a rate of 450 tpd at a cost approaching $10 million. This property was being developed for production in 1975 but the work was halted when the price of gold dropped abruptly.

Agnico-Eagle Mines Limited announced that it will sink a 1 220 m shaft on the leased Telbel property adjacent to the company's Eagle mine. This will provide access to the southeasterly extension of the orebody. Camflo Mines Limited and Malartic Hygrade Gold Mines (Canada) Limited negotiated an agreement that allows Camflo to mine that portion of its orebody extending into the Hygrade ground. Drilling from the Camflo workings has outlined substantial new ore reserves. Malartic Hygrade will receive 60 per cent of net profits from development of its ground.

In May the Ferderber Mine, owned by Belmoral Mines Ltd., was flooded with mud and water from the overlying swamp. Clean-up, including recovery of the bodies of eight men killed in the cave-in, required several months. Production resumed November 3. An inquiry held by the Quebec government determined that the cave-in was due to a fault in the crown pillar that was not discovered in the drilling program. The final report, issued at the beginning of April 1981, stated that the company had indications that a problem was developing but did not

TABLE 2. CANADA, GOLD PRODUCTION BY SOURCE, 1970 and 1975-80

	Auriferous Quartz Mines		Placer Operations		Base-Metal Ores		Total	
	(grams)	(%)	(grams)	(%)	(grams)	(%)	(grams)	(%)
1970	58 591 610	78.2	228 890	0.3	16 094 525	21.5	74 915 025	100.0
1975	37 529 456	73.0	335 077	0.6	13 568 581	26.4	51 433 114	100.0
1976	38 333 013	72.8	517 375	1.0	13 770 722	26.2	52 621 110	100.0
1977	37 831 875	70.1	526 986	1.0	15 562 469	28.9	53 921 330	100.0
1978	36 339 934^{r}	67.3	555 663^{r}	1.0^{r}	17 071 330^{r}	31.7^{r}	53 966 927	100.0
1979	33 794 332	66.1	899 202	1.7	16 448 825	32.2	51 142 359	100.0
1980P	31 150 000^{e}	60.9	2 492 000^{e}	4.9	17 500 000^{e}	34.2	51 142 000	100.0

Sources: Statistics Canada; Energy, Mines and Resources Canada.

P Preliminary; ^{r} Revised; ^{e} Estimated.

TABLE 3. CANADA, GOLD PRODUCTION, AVERAGE VALUE PER GRAM AND RELATIONSHIP TO TOTAL VALUE OF ALL MINERAL PRODUCTION[1], 1970 AND 1975-80

	Total Production	Total Value	Average Value per Gram[2]	Gold as per cent of Total Value of Mineral Production
	(grams)	($ Cdn)	($ Cdn)	(%)
1970	74 915 025	88,057,464	1.18	1.5
1975	51 433 114	270,830,389	5.27	2.0
1976	52 621 110	208,273,405	3.96	1.4
1977	53 921 330	272,331,217	5.05	1.5
1978	53 966 927	382,423,117	7.09	1.9
1979	51 142 359	590,766,328	11.55	2.3
1980P	50 620 000	1,165,417,000	23.02	3.3

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Includes structural minerals and mineral fuels. [2] Value not necessarily based on average gold price for 1980.

P Preliminary.

exercise sufficient caution. Criminal charges are being considered.

Gold exploration activity in Quebec was vigorous during 1980, particularly in the historic gold producing area between Malartic and Val d'Or known as "the Cadillac Break". Exploration has received firm support from the provincial government which hopes to see Quebec become Canada's leading gold producing province. Sufficient work has been done on a number of properties, notably the Kewagama property, the Gold Hawk property, the Chibex property and the Pandora property, to suggest that additional production decisions will be announced in 1981.

Ontario. Total gold production in Ontario in 1980 was 18 384 kg, a decrease from 1979. Lode gold mines accounted for 90 per cent of output, with the balance derived from base-metal ores.

Campbell Red Lake Mines Limited, in the Red Lake district, continued to be the leading gold producer in Canada with an output in 1980 of 5 895 kg and bullion revenue of

$136,314,000, up from $70,055,000 in 1979. The dramatic increase in revenue was primarily due to the record price for gold bullion. However production was augmented by gold recovered from a thorough clean-up of mill equipment taken out of service during the expansion program. Accumulation of gold in the crevasses and crannies of a gold mill circuit over a period of time is substantial. Expansion, planned to come on-stream through 1981 and 1982, will raise output to 6 600 kg gold per year from lower grade ore.

Pamour Porcupine Mines, Limited is continuing exploration on former producing properties and gold prospects in the Timmins district to ensure a continuing supply of feed for its two central mills. A major undertaking is the re-entry of the upper levels of the former Hollinger Mine (now referred to as the Timmins property). The Hollinger, in production from 1910 until 1968, yielded over 19 million troy ounces of gold (590 957 kg) and was by far the leading gold producer of the Timmins camp. Pamour estimates that there is potential for 1.9 million t of ore grading 4.11 g/t. $15 million has been budgeted to rehabilitate the main shaft and commence production at 775 tpd by late 1982. Pamour is also reopening its No. 2 mine (the former Hallnor property) and has signed a letter of intent with Broulan Reef Mines Limited to reactivate the Broulan property which adjoins Pamour's Nos. 1 and 2 mines. A priority for Pamour is to improve the tonnage and grade of its proven ore reserves which at the end of 1980 stood at 3.9 million t averaging 2.81 g/t gold and 0.28 per cent copper.

During the fall, Texasgulf Inc. began surface stripping on the Owl Creek gold deposit owned jointly (60 per cent/40 per cent) with Inco Limited, to develop the open-pit portion of the orebody. Texasgulf will likely add a gold circuit in its existing mill to handle ore from Owl Creek and possibly from its wholly owned Hoyle Pond deposit where three sub-vertical but parallel mineralized zones have been located. This deposit is beneath the tailings pond of the Texasgulf concentrator and would be developed as an underground mine. Owl Creek and Hoyle Pond together could produce between 500 and 800 tpd. Drill indicated reserves at Owl Creek are 2.27 million t grading 5.14 g/t gold. Reserves have not been announced for Hoyle Pond. Texasgulf will also be producing gold from two locations in the United States in 1981; Iron Dyke in Oregon and Cripple Creek in Colorado.

The exploration program and feasibility study carried out during 1980 by the partners in the Detour Lake Joint Venture culminated in January 1981 with the announcement that the property will be developed for production with start-up scheduled for October 1, 1983. The consortium consists of Amoco Canada Petroleum Company Ltd., the discoverer of the orebody, which holds a 50 per cent interest and Dome Mines, Limited and Campbell Red Lake Mines Limited which have each earned a 25 per cent interest. Campbell Red Lake is the operating company. Initital production will be at 2 000 tpd from an open-pit. Production from underground is scheduled for 1987 when milling capacity will be increased to 4 000 tpd. Costs to production in 1983 are estimated at $143 million. Probable ore reserves at the end of 1980 were 27 733 000 t grading 3.88 g of gold per t, 4.66 g of silver per t and 0.205 per cent copper. The mill will be the first in Canada to utilize carbon-in-pulp gold recovery. Agreement in principle has been reached with the Ontario government regarding construction of 150 km of road to provide access from the Cochrane-Iroquois Falls area which will likely be home for most of the employees.

At the Dome mine, in production since 1910 and Canada's longest-operating gold mine, a 50 per cent mill expansion to be completed in 1984 will increase capacity from 1 820 to 2 720 tpd and gold output from 2 675 to 3 700 kg/yr. Mine development will include a new 1 646 m shaft from surface. Capital cost, including escalation, is put at $91,900,000.

The scale of operations at the Kerr Addison Mines Limited mine is gradually being reduced as reserves become depleted. Continuing operations depend in part on the price of gold being maintained.

Dickenson Mines Limited has embarked on an overhaul and expansion of the Dickenson Mine at a cost of $10 million to be completed in 1982 which will raise production capacity from 275 tpd to 820 tpd.

As in Quebec, gold exploration in Ontario was very active throughout 1980, particularly in areas with a history of gold production. Northgate Exploration Limited is planning a small scale open-pit operation for the Ashigami property in Scadding Township, 40 km northeast of Sudbury. Drilling on the Orofino property, 104 km southwest of Timmins, has been sufficiently encouraging that Northgate is planning engineering, economic and environmental studies that may lead to a production-sized shaft for underground exploration in 1981-82. Rengold Mines & Resources Ltd. hopes to reopen the Rengold Mine (formerly the Renabie Mine). This mine was in production from 1947 to 1970 and again in 1975 to 1976, when it was forced into receivership when the price of gold fell. Goldlund Mines Limited continued exploration of its property near Dryden, and Quebec Sturgeon River Mines Limited resumed activity on its partially developed Stock Township property near Timmins.

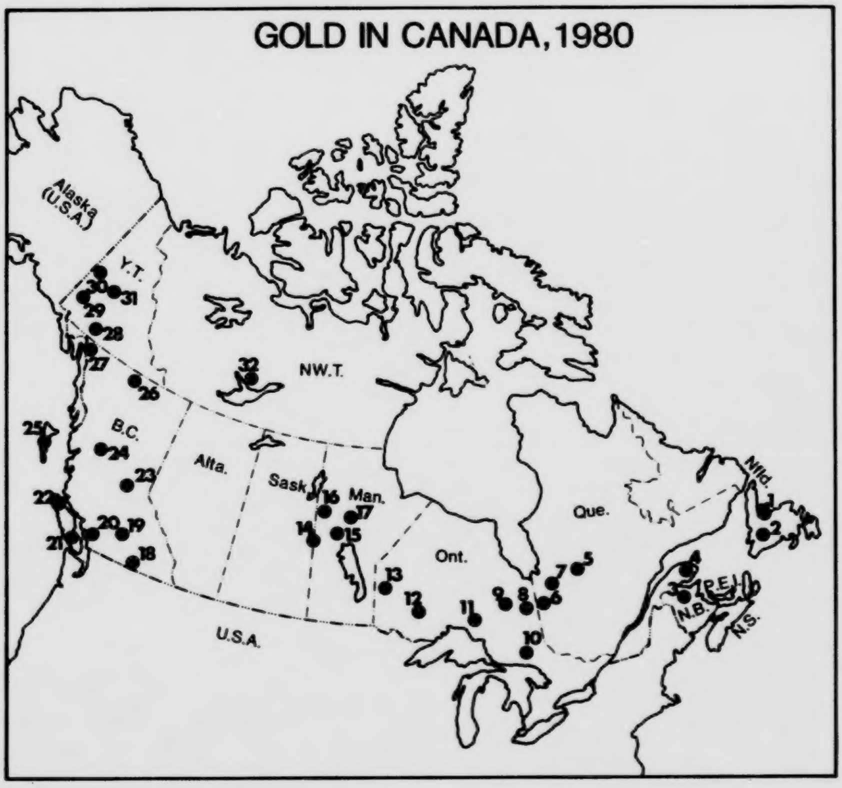
Activity on a number of other properties may lead to small scale production (100-200 tpd) during the coming year. It is possible to bring in small gold mines on fairly short notice using small mills and for a modest ($3-5 million) capital investment.

Prairie Provinces. Virtually all gold produced in the Prairie provinces was recovered as a byproduct of base-metal ores. A small amount of gold was recovered by gravel-washing plants on the North Saskatchewan River, near Edmonton, Alberta. Exploration activity has resumed in the former gold producing areas of Manitoba, principally in the Bissett area of eastern Manitoba and the Snow Lake and Lynn Lake areas of northwestern Manitoba. Brinco Limited has entered into a joint venture agreement with New Forty-Four Mines Limited that may lead to the reopening of the San Antonio Mine. The mine closed in 1968 due to high operating costs and it is estimated that some 726 000 t grading 7.9 g/t remain. The property requires a new shaft and a mill. Hudson Bay Mining and Smelting Co., Limited has a two-year agreement to examine the Nor-Acme property near Snow Lake, in production from 1949 to 1958. Sherritt Gordon Mines Limited has optioned the Agassiz deposit near Lynn Lake and commenced a drilling program. Junior mining and exploration companies are examining gold showings in various parts of the province.

British Columbia. In British Columbia, Carolin Mines Ltd. continued with development of its Ladner Creek property near Hope and expects to have the mill in operation by spring 1981. Milling rate will be 1 360 tpd and production costs are estimated at $100 per ounce of gold (1979 dollars). Scottie Gold Mines Ltd., with financing provided in part by its major shareholder, Northair Mines Ltd., continued development of its gold property near Stewart. Production is scheduled for June 1981 and capital costs are expected to approximate $19 million. Du Pont Canada Inc. proceeded with development of its Baker gold-silver property 270 km north of Smithers. Production is scheduled to begin in March 1981 from a 100 tpd cyanide mill, with ore coming from two adits and a small open-pit. Development costs are expected to total about $12 million. Mineable reserves of 90 700 t grading 30.89 g/t Au and 651.4 g/t Ag are sufficient for three years and exploration is continuing. Cusac Industries Ltd. brought its property near Cassiar into production at a milling rate of 30 to 50 tpd. This is a seasonal operation that closes from December through March. United Hearne Resources Ltd. and Taurus Resources Ltd. are preparing the Taurus property, also near Cassiar, for production at 90 tpd by mid-1981. The Cassiar area, most recently known for asbestos production, is a former placer gold producing area and placer mining is becoming active. Near Wells, The Mosquito Creek Gold Mining Company Limited began production from its property at 35 tpd, later increased to 70 tpd. The mill has a capacity of 90 tpd.

Consolidated Cinola Mines Ltd. continued work on its large, low-grade gold prospect in the Queen Charlotte Islands. Reserves are now placed at 40.8 million t grading 1.85 g/t Au. Capital costs of an open-pit mine and a 9 000 tpd mill are now estimated at $171 million. Pilot plant milling studies are scheduled for 1981.

Yukon Territory. 2 271 kg of crude gold was reported from Yukon placer mines in 1980 and since not all production is reported, output may have approached 3 110 kg. Approximately 70 per cent of production comes from the Dawson area, 15 per cent from the Mayo area and the remaining 15 per cent from other parts of the territory principally the Whitehorse district. Claim staking activity, which had diminished with the lower gold prices prevailing during 1977 and 1978 picked up sharply in 1979 and 1980. All of the streams from which gold production has been reported at some time in the past are solidly staked and prospectors must now seek remote and untried areas. Placer mining has become an earth moving operation utilizing large dozers, scrapers


GOLD IN CANADA, 1980
Alaska (U.S.A.)
Y.T.
NW.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
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31
32

GOLD PRODUCERS 1980

(numbers refer to numbers on map above)

Newfoundland

(1) Consolidated Rambler Mines Limited (a)
(2) ASARCO Incorporated (Buchans Unit) (a)

New Brunswick

(3) Heath Steele Mines Limited (a)

Quebec

(4) Gaspé Copper Mines, Limited

(5) Chibougamau district
    Campbell Resources Inc. (a) (b)
    Corporation Falconbridge Copper (Opemiska Division) (a)
    Lemoine Mines Limited (a)
    Patino Mines (Quebec) Limited (Copper Rand Division) (a)

(6) Noranda Rouyn district

    Corporation Falconbridge Copper (Lake Dufault Division) (a)
    Noranda Mines Limited - Chadbourne mine (b)

(6) Malartic - Val d'Or district

    Camflo Mines Limited (b)
    Les Mines Est Malartic Ltée (b)
    Lamaque Mining Company Limited (b)
    Sigma Mines (Quebec) Limited (b)
    Louvem Mining Company Inc. ((b)
    Darius Gold Mines Inc. (b)
    Les Mines d'Or Thompson-Bousquet Ltée (b)
    Belmoral Mines Ltd. (b)
    Silverstack Mines Ltd. (b)

(7) Matagami district

Agnico-Eagle Mines Limited (b)
Mattagami Lake Mines Limited (a)
Noranda Mines Limited (Orchan Division) (a)

Ontario

(8) Larder Lake Mining Division

Kerr Addison Mines Limited (b)
Pamour Porcupine Mines, Limited (Ross Mine) (b)
Willroy Mines Limited (Macassa Division) (b)

(9) Porcupine Mining Division

Dome Mines, Limited (b)
Pamour Porcupine Mines, Limited (Nos. 1 & 3 mines and Timmins property) (b)
Pamour Porcupine Mines, Limited (Schumacher Division McIntyre mine) (a) (b)

(10) Sudbury Mining Division

Falconbridge Nickel Mines Limited (a)
Inco Limited (a)

(11) Thunder Bay Mining Division

Noranda Mines Limited (Geco Mine) (a)

(12) Patricia Mining Division

Corporation Falconbridge Copper (Sturgeon Lake Division) (a)

(13) Red Lake Mining Division

Campbell Red Lake Mines Limited (b)
Dickenson Mines Limited (b)
Dickenson Mines Limitée (Robin Red Lake Division) (b)

Manitoba

(14) Hudson Bay Mining and Smelting Co., Limited (Flin Flon) (a)
(15) Hudson Bay Mining and Smelting Co., Limited (Snow Lake) (a)
(16) Sherritt Gordon Mines Limited (Fox Lake & Ruttan mines) (a)
(17) Inco Limited (a)

British Columbia

(18) Cominco Ltd. (a)
(19) Afton Mines Ltd. (a)
Brenda Mines Ltd. (a)
Similkameen Mining Company Limited (a)
Dankoe Mines Ltd. (b)
(20) Northair Mines Ltd. (a)
(21) Western Mines Limited (a)
(22) Utah Mines Ltd. (Island Copper Mine) (a)
(23) Small Placer operations (c)
(24) Noranda Mines Limited (Bell Copper Mine) (a)
(25) Wesfrob Mines Limited (a)
(26) Erickson Gold Mining Corp. (b)
(27) Small Placer operations (c)

Yukon Territory

(28) Hudson Bay Mining and Smelting Co., Limited (Whitehorse Copper Division) (a)
(29) Small placer operations (c)
(30) Small placer operations (c)
(31) Small placer operations (c)

Northwest Territories

(32) Cominco Ltd. (Con Mine) (b)
Giant Yellowknife Mines Limited (b)
Lolor Mines Limited (b)
Rycon Mines Limited (b)
Supercrest Mines Limited (b)

(a) base-metal, gold byproduct
(b) lode gold
(c) placer gold

and front end loaders to move gravel to the sluice boxes, monitors to wash away thawing overburden and recycle ponds to ensure enough water for sluicing. One small dredge has been restored to operating condition.

There are no operating lode gold mines in the Yukon but there is now some lode gold exploration activity. United Keno Hill Mines Limited entered an agreement with Tagish Lake Syndicate to reexamine and possibly reopen the Venus gold-silver mine near Carcross. A significant quantity of gold was recovered as a byproduct from the copper mine of Hudson Bay Mining and Smelting Co., Limited, Whitehorse Copper Division.

Northwest Territories. All gold produced in the Northwest Territories in 1980 came from the lode gold mines in the Yellowknife district. East of Yellowknife, Pamour Porcupine Mines, Limited began production at the Camlaren property of Discovery Mines Limited. This small tonnage, high-grade property (50 800 t of 21.25 g/t Au) was partially developed in 1975 when the drop in the price of gold caused development to be suspended. Pamour brought the property into production on a seasonal basis using a portable mill at a cost of $900,000. The property has an estimated production life of about three years. IU International Corporation, through wholly owned Echo Bay Mines Ltd., will begin production at 900 tpd from its Lupin property at Contwoyto Lake, 300 km north of Yellowknife, in 1982.

In the District of Keewatin, Cullaton Lake Gold Mines Ltd. will bring its property south of Baker Lake into production at 180 tpd by the end of 1981. A $25 million financing package was arranged with Inuit Development Corporation, an organization dealing with the business and financial aspects of development on Inuit lands.

REGULATORY ACTIVITY

Regulations came into force on July 1, 1980, that limit emissions of arsenic from gold roasting operations to 20 mg per standard cubic metre (SCM) for operations using direct cooling, 75 mg per SCM for operations using indirect cooling, and 20 mg per SCM for handling operations associated with the disposal of the collected arsenic dust. The four Canadian gold mines that currently roast arsenic-bearing sulphide concentrates and are affected by the regulations are Giant Yellowknife Mines Limited, Campbell Red Lake Mines Limited, Dickenson Mines Limited, and Kerr Addison Mines Limited.

The Yukon Placer Mining Act, little changed since it was established in 1906, does not meet the requirements of modern placer mining and is under review.

GOLD COIN PROGRAM

1980 marked the first full year of operation of the "Gold Maple Leaf" bullion coin program. The authorized minting of the one troy ounce coins was 2 million for the year, but sales lagged somewhat due to the high gold price, and the total minting for 1980 was 1.5 million. Sales amounted to 1,215,000 coins and revenue to the Royal Canadian Mint was reported as $1.6 billion. More than 80 per cent of this revenue was realized from foreign sales.

The selling price to distributors is based on the price of gold (established daily) plus a premium (currently 3 per cent) to cover manufacturing and distribution costs plus a modest profit to the Mint. The total premium paid by final purchasers amounts to 6 or 7 per cent, with provincial sales tax applicable in most provinces. The coin has a diameter of 30 mm, a thickness of 2.8 mm and contains only Canadian-produced gold. As Canadian gold production amounts to about 1,500,000 ounces per year, the bullion coin program may absorb all production and if the full authorized minting of 2 million coins is achieved in 1981, the Mint will have to draw on stocks held as part of Canada's official monetary reserves.

As Canadian gold producers can readily sell their entire output on the open market, the gold bullion coin program will not directly affect the demand for Canadian-produced gold. By appealing to those who wish to hold gold as a part of their investments but are sensitive to the source, it may increase total world demand, thereby helping to sustain the price. Total annual world gold production is currently estimated at 1 000 t (32.2 million troy oz.)so that gold consumed in production of the "Gold Maple Leaf" will be between 3 and 6 per cent of world production in 1980 and 1981.

The Canadian government minted a legal tender gold coin in 1980 to commemorate the 1880 transfer of Arctic Territories to Canada from Britain. Production of the $100 face

TABLE 4. PRINCIPAL GOLD (MINE) PRODUCERS IN CANADA, 1980 AND (1979)

Company and Location	Mill or Mine Capacity (tonnes of ore/day)	Grade of Ore Treated				Ore Treated (tonnes)	Gold contained in Concentrate (kilograms)	Remarks
		Gold (grams/tonne)	Silver (grams/tonne)	Copper %	Combined Lead and Zinc %			
NEWFOUNDLAND								
ASARCO Incorporated, (Buchans Unit), Buchans	1 100 (1 100)	0.82 (0.82)	102.51 (109.71)	0.85 (1.04)	14.8 (18.15)	75 296 (113 398)	49.4 (76.1)	Property continues to operate on salvage basis.
Consolidated Rambler Mines Limited, Baie Verte	1 100 (1 100)	2.09 (2.67)	18.55 (23.52)	3.51 (3.90)	- (-)	164 281 (196 918)	251.0 (351.4)	Limited ore reserves.
NEW BRUNSWICK								
Heath Steele Mines Limited, Newcastle	3 650 (3 650)	1.03 (0.69)	55.20 (55.20)	0.84 (0.91)	5.79 (6.08)	1 252 406 (1 172 737)	417.5 (263.3)	
QUEBEC								
Agnico-Eagle Mines Limited, Joutel	1 000 (1 000)	5.76 (6.58)	1.23 (1.71)	- (-)	- (-)	324 241 (333 481)	1 716.3 (2 010.9)	Planning expansion to develop adjacent Telbel property.
Belmoral Mines Ltd. Val d'Or	660 (500)	5.48 (6.79)	1.03e (-)	- (-)	- (-)	65 847 (26 900)		Production interrupted June through October by cave-in. Construction of own mill completed.
Camflo Mines Limited, Malartic	1 150 (1 170)	3.94 (5.38)	0.12 (0.14)	- (-)	- (-)	419 983 (427 013)	1 570.0 (2 196.6)	
Campbell Resources Inc. Cedar Bay, Henderson and Merrill Pit copper, gold mines, Gwillim gold mine, Chibougamau	2 950 (2 950)	2.78 (2.26)	6.86 (7.54)	0.99 (1.17)	- (-)	390 981 (396 822)	872.5 (772.8)	Gwillim gold mine brought into production.
Darius Gold Mine Inc. Val d'Or	225	3.43	0.12	-	-	33 387	106.4	Darius hopes to develop large tonnage low grade operation.

TABLE 4. (Cont'd.)

Company and Location	Combined Mine Capacity	Grade of Ore Treated: Gold	Grade of Ore Treated: Silver	Grade of Ore Treated: Copper	Grade of Ore Treated: Combined Lead and Zinc	Ore Treated	Gold contained in Concentrate	Remarks
	(tonnes of ore/day)	(grams/ tonne)	(grams/ tonne)	%	%	(tonnes)	(kilograms)	
QUEBEC (cont'd.)								
Corporation Falconbridge Copper, Lake Dufault Division, Millenbach and Norbec mines, Rouyn-Noranda	1 450 (1 400)	0.72 (0.89	28.80 (48.69)	2.70 (3.60)	2.19 (4.90)	475 464 (419 827)	261.9 (316.6)	
Corporation Falconbridge Copper, Opemiska Division Perry, Springer and Cooke mines, Chapais	2 600 (2 600)	1.23 (1.34)	10.29 (12.34)	1.57 (1.79)	- (-)	964 052 (954 801)	1 004.1 (1 064.7)	
Gaspé Copper Mines, Limited Copper Mt. Mill Murdochville	27 125 (27 735)	0.055 (0.07)	2.89 (2.74)	0.45 (0.43)	- (-)	8 875 542 (5 065 084)	43.7 (34.1)	
Gaspé Copper Mines, Limited Needle Mt. Mill Murdochville	3 700 (2 930)	0.07 (0.07)	6.17 (6.86)	1.02 (1.24)	- (-)	1 350 780 (570 510)	22.3 (9.5)	
Lamaque Mining Company Limited Val d'Or	1 900 (1 900)	3.20 (3.63)	0.48 (0.55)	- (-)	- (-)	399 260 (392 793)	1 008.4 (1 326.3)	Limited reserves.
Les Mines d'Or Thompson-Bousquet Ltée. Malartic	(725)	(7.89)	(0.82)	-	-	(52 814)	(378.0)	Commenced operation July 1979. Ore trucked to Les Mines Est-Malartic Ltée mill.
Little Long Lac Gold Mines Limited East Malartic Mill	590 (1 630)	5.14 (4.08)	0.55 (0.75)	- (-)	- (-)	175 798 (433 630)	788.6 (1 739.7)	Est Malartic mill and Malartic Gold Fields
Malartic Gold Fields Mill Malartic	1 000 (725)	6.48 (7.89)	0.67 (0.82)	- (-)	- (-)	296 695 (52 814)	1 916.2 (378.0)	Mill available for custom milling.
Louvem Mining Company Inc., Val d'Or	900 (900)	1.82 (0.93)	30.38 (137.83)	0.15 (0.04)	4.00 (5.06)	224 530 (72 261)	229.9 (48.9)	
Mattagami Lake Mines Limited, Matagami	4 000 (4 000)	0.51 (0.58)	21.39 (26.85)	0.77 (0.73)	4.81 (5.37)	1 328 360 (1 329 428)	305.9 (244.9)	Merged into Noranda Mines Ltd. in fall 1979.

Noranda Mines Limited Horne Mill (Chadbourne Circuit) Noranda	1 800 (1 800)	3.74 (4.66)	3.43 (4.18)	- (-)	- (-)	257 239 (93 154)	869.3 (390.3)	Chadbourne Mine began production in July 1979.
Patino Mines (Quebec) Limited, Lemoine Mill, Chibougamau	300 (300)	5.14 (5.25)	88.80 (92.91)	4.71 (5.07)	10.00 (11.61)	104 326 (108 267)	965.6 (510.8)	
Patino Mines (Quebec) Limited, Patino Mill	2 500 (2 170)	2.95 (3.19)	9.22 (9.50)	1.68 (1.64)	- (-)	615 035 (606 995)	1 519.5 (1 612.2)	
Sigma Mines (Quebec) Limited, Val d'Or	1 270 (1 315)	3.94 (4.89)	0.79 (0.93)	- (-)	- (-)	438 942 (445 752)	1 669.0 (2 111.5)	Mine reserves being re-evaluated in light of improved gold prices.
ONTARIO								
Campbell Red Lake Mines Limited, Red Lake	750 (750)	21.87 (22.49)	2.40 (..)	- (-)	- (-)	275 600 (272 314)	5 676.9 (5 754.3)	Planned expansion completed.
Dickenson Mines Limited, Red Lake	455 (455)	9.26 (13.89)	1.03 (1.41)	- (-)	- (-)	116 283 (106 790)	910.7 (1 381.0)	Dickenson plans to expand mine/mill capacity to 815 t/d.
Dome Mines, Limited, South Porcupine	1 800 (1 800)	4.53 (5.11)	0.69 (0.81)	- (-)	- (-)	615 162 (602 280)	2 649.9 (2 945.6)	Mine/mill capacity to be increased from 1 185 to 2 720 tpd.
Corporation Falconbridge Copper, Sturgeon Lake Joint Venture Sturgeon Lake	1 090 (1 090)	0.48 (0.62)	131.66 (169.71)	1.46 (2.17)	6.94 (9.93)	371 623 (373 953)	80.7 (154.1)	
Falconbridge Nickel Mines Limited, Sudbury district	7 620 (10 340)	0.07 (0.07)	3.43 (3.43)	0.94 (0.85)	- (-)	2 182 765 (2 500 190)	75.3 (172.4)	Gold and silver grades are Mineral Policy Sector estimates.
Inco Limited, Sudbury and Shebandowan districts	49 450 (49 500)	0.17 (0.17)	4.46 (4.46)	1.30 (1.39)	- (-)	10 608 845 (5 339 227)	1 109.4 (544.6)	Gold and silver grades are Mineral Policy Sector estimates.
Kerr Addison Mines Limited, Virginiatown	1 225 (1 225)[1]	9.60 (11.31)	0.41 (0.69)	- (-)	- (-)	194 768 (175 029)	1 804.5 (1 938.8)	Limited ore reserves. Improved gold prices should allow continued production through 1982.
Mattabi Mines Limited, Sturgeon Lake	2 720 (2 720)	0.00 (0.38)	106.63 (97.71)	0.44 (0.55)	8.11 (7.68)	846 940 (945 015)	0.0 (194.2)	

TABLE 4. (Cont'd.)

Company and Location	Combined Mine Capacity (tonnes of ore/day)	Grade of Ore Treated: Gold (grams/tonne)	Grade of Ore Treated: Silver (grams/tonne)	Grade of Ore Treated: Copper %	Grade of Ore Treated: Combined Lead and Zinc %	Ore Treated (tonnes)	Gold contained in Concentrate (kilograms)	Remarks
ONTARIO (cont'd.)								
Noranda Mines Limited Geco Division Manitouwadge	4 535 (4 535)	0.10 (0.10)	60.69 (58.97)	1.47 (1.82)	3.46 (3.35)	1 358 317 (1 475 841)	87.4 (113.0)	
Pamour Porcupine Mines, Limited, Pamour Division Timmins	2 720 (2 720)[1]	2.85 (3.19)	0.69 (0.41)	- (-)	- (-)	931 956 (848 806)	2 523.3 (2 469.0)	Re-evaluation of ore reserves in progress. Exploration on nearby properties continues.
Pamour Porcupine Mines, Limited, Schumacher Division Schumacher	2 720 (2 720)[1]	2.19 (2.96)	2.85 (3.43)	0.25 (0.25)	- (-)	845 982 (728 079)	1 550.1 (1 769.0)	
Willroy Mines Limited, Macassa Division, Kirkland Lake	320 (320)	16.11 (17.73)	2.74 (2.67)	- (-)	- (-)	100 675 (95 717)	1 554.8 (1 637.4)	Exploration program on adjacent claim blocks.
MANITOBA - SASKATCHEWAN								
Hudson Bay Mining and Smelting Co., Limited,	7 250 (7 250)	1.30 (1.22)	19.78 (20.86)	1.67 (1.99)	2.26 (2.89)	945 379 (1 253 875)	725.5 (959.6)	
Flin Flon Mill Snow Lake Mill	3 450 (3 450)	1.10 (0.95)	16.66 (12.29)	2.65 (2.87)	3.46 (3.69)	756 283 (446 947)	462.1 (234.0)	
Inco Limited Thompson	12 700 (12 700)	0.10 (0.10)	2.74 (2.74)	0.13 (0.14)	- (..)	2 557 454 (2 269 680)	160.5 (142.4)	Gold and silver grades are Mineral Policy Sector estimates.
Sherritt Gordon Mines Limited, Fox mine, Lynn Lake	2 700 (2 700)	0.27 (0.17)	6.51 (4.69)	1.40 (1.19)	1.56 (1.82)	784 011 (772 500)	191.3 (121.0)	
Sherritt Gordon Mines Limited, Ruttan Mine Leaf Rapids	9 100 (9 100)	0.27 (0.21)	6.51 (5.60)	1.36 (1.39)	1.02 (1.17)	2 311 444 (2 094 159)	484.2 (408.7)	

BRITISH COLUMBIA

Afton Mines Ltd., Kamloops	7 700 (7 700)	0.65 (0.79)	5.07 (4.90)	1.05 (1.06)	- (-)	2 739 799 (2 822 528)	1 315.5 (1 744.4)	
Bethlehem Copper Corporation Highland Valley	17 690 (17 690)	0.03 (0.04)	1.78 (2.13)	0.38 (0.41)	- (-)	6 281 347 (6 536 861)	92.8 (135.0)	
Brenda Mines Ltd. Peachland	27 220 (27 220)	0.02 (0.02)	1.10 (1.27)	0.13 (0.14)	- (-)	9 126 857 (9 075 720)	85.2 (103.1)	
Dankoe Mines Ltd. Keremeos	400 (400)	0.39 (0.86)	136.08 (250.29)	- (0.02)	0.27 (0.21)	30 028 (25 536)	9.4 (18.8)	
DeKalb Mining Corporation Highland Valley	635	0.39	20.19	1.93	-	48 234	17.0	
Erickson Gold Mining Corp., Cassiar	95 (135)	19.99 (13.19)	21.87 (22.39)	-	-	29 201 (28 896)	560.2 (590.9)	Mill expansion to 180 tpd planned for 1981.
The Mosquito Creek Gold Mining Company Limited	64	16.15	4.29	-	-	11 419	136.8	
Newmont Mines Limited, Granduc Operating Division, Stewart	..	..	..		-	..	..	Closed June 30, 1978. Scheduled to be reopened by Esso Minerals Canada in 1980.
Newmont Mines Limited, Similkameen Division, Princeton	20 000 (20 000)	0.34 (0.34)	1.47 (1.20)	0.46 (0.44)	- (-)	6 612 470 (7 034 952)	1 168.8 (1 178.3)	Developing Copper Mountain orebodies.
Noranda Mines Limited, Babine Division, Bell Copper Mine	15 420 (9 100)	0.34 (0.27)	- (..)	0.41 (0.35)	- (-)	5 012 196 (5 073 909)	797.4 (727.8)	Mill expansion to be completed by 1981.
Granisle Mine Babine Lake	11 880 (12 700)	0.21 (0.24)	2.06 (2.40)	0.39 (0.45)	- (-)	3 936 725 (4 382 909)	387.1 (498.2)	
Northair Mines Ltd., Brandywine Mine	270 (300)	8.37 (11.35)	32.33 (26.33)	0.50 (0.50)	3.59 (2.41)	71 478 (91 587)	550.5 (923.5)	Ore reserves limited.
Placer Development Limited Equity Silver	4 540	0.96	126.86	0.38	-	448 000	258.2	
Utah Mines Ltd., Island Copper Mine, Coal Harbour, Vancouver Island	37 200 (37 200)	0.27 (0.24)	1.82 (1.68)	0.42 (0.45)	- (-)	13 757 175 (13 339 997)	1 779.6 (1 674.0)	

TABLE 4. (Cont'd.)

Company and Location	Combined Mine Capacity (tonnes of ore/day)	Grade of Ore Treated				Ore Treated (tonnes)	Gold contained in Concentrate (kilograms)	Remarks
		Gold (grams/tonne)	Silver (grams/tonne)	Copper %	Combined Lead and Zinc %			
BRITISH COLUMBIA (Cont'd.)								
Wesfrob Mines Limited Tasu	5 440 (7 250)	0.07 (0.10)	3.12 (4.46)	0.27 (0.37)	- (-)	996 432 (1 009 247)	55.7 (84.5)	
Western Mines Limited Buttle Lake, Vancouver Island	900 (900)	2.74 (2.91)	124.11 (131.31)	1.22 (1.32)	8.81 (9.82)	278 244 (266 877)	654.8 (638.7)	
YUKON TERRITORY								
Cyprus Anvil Mining Corporation	9 300 (9 075)	0.25 (0.10)	47.01 (25.03)	- (-)	7.80 (8.54)	2 825 150 (2 823 031)	371.7 (231.0)	
Hudson Bay Mining and Smelting Co., Limited Whitehorse	2 270 (2 350)	0.96 (0.69)	10.29 (7.20)	1.58 (1.12)	- (-)	775 013 (829 221)	674.1 (493.6)	
NORTHWEST TERRITORIES								
Cominco Ltd., Con and Rycon mines, Yellowknife	590 (590)	16.46 (15.77)	4.29 (3.67)	- (-)	- (-)	192 303 (196 469)	3 013.3 (2 955.1)	
Discovery Mines Limited Camlaren Mill	136	16.18	4.80	-	-	11 142	147.3	Seasonal production (March-November). Joint venture of Discovery and Noranda Mines with Pamour as operator.
Giant Yellowknife Mines Limited, Yellowknife	1 100 (1 100)	6.72 (7.06)	1.37 (2.06)	- (-)	- (-)	206 149 (377 621)	1 190.7 (2 336.1)	Mine shut down by strike July 10 - Oct. 24.
Lolor Mines Limited, Yellowknife	.. (26)[1]	.. (11.07)	.. (..)	- (-)	- (-)	Included with Giant		Ore treated at Giant Mill.
Supercrest Mines Limited, Yellowknife	.. (53)[1]	.. (13.41)	.. (..)	- (-)	- (-)	Included with Giant		Ore treated at Giant mill.

Source: Federal/Provincial questionnaire survey of companies with producing mines in Canada. This data is supplied on a calendar year basis. In previous annual reviews most of the data was obtained from company annual reports based on the corporate fiscal year. Thus there are some discrepancies between the above statistics and those reported in the 1978 annual review.

[1] Average daily tonnage milled.

- Nil; .. Not available

value gold coin, containing half an ounce of fine gold, was set at 300,000 coins. The selling price was fixed at $430 each.

In 1981 the Royal Canadian Mint will strike a one half troy ounce gold coin commemorating the adoption of 'O Canada' as the national anthem. The coin will have a face value of $100 and the minting will be limited to 250,000 coins.

WORLD INDUSTRY

Consolidated Gold Fields Limited, in its report "Gold 1981", estimated total non-communist world gold production in 1980 at 943.0 t compared with 961.3 t in 1979. The Republic of South Africa is by far the leading gold producing country, followed by the U.S.S.R. Other significant producers, in decreasing order of importance[1], were Canada, Brazil, the United States, the Philippines, Australia and Mexico. South African production in 1980 is estimated at 675.0 t (71.6 per cent of the non-communist world total), down from 703.3 t in 1979. By comparison, Canada accounted for only 5 per cent. Gold production in the People's Republic of China is not reported but recent estimates based on visits by western mining industry personnel place production in the range of 30-60 t/y, similar to that in Canada and the United States. Estimates of Brazilian production have recently been revised upward giving more weight to the output of the thousands of individual alluvial miners or garimpeiros which is not accurately measurable.

The world's major centres for gold distribution are London, where gold sales are handled largely through members of the London Gold Market, the group that sets the morning and afternoon London Gold Market fixing prices; and Zurich, where sales are handled through banks. Hong Kong has also become an active gold trading centre. The Republic of South Africa is a major supplier of gold to these markets, supplemented by the U.S.S.R especially to the Swiss market.

According to "Gold 1981", supply of gold in the non-communist world fell sharply in 1980 to 1 033 t from 1 704 t in 1979. The decrease is accounted for by the decline in sales from the eastern bloc, the completion of the IMF sales in May, the absence of U.S. Treasury sales and the absorption into government reserves of some South African output. Of the available supply, 230 t were purchased by the official sector.

WORLD PRODUCTION

Production was lower in 1980 than in 1979 due to depletion at some mines and treatment of lower-grade ores (because of higher gold prices) at others. Production from new mines developed in response to higher prices will not be sufficient to offset the decline before 1981 and world production is unlikely to show an increase before 1982. Estimates of Soviet production made by different sources vary so widely that comparison of total annual world gold production from one year to the next is somewhat unrealistic.

Republic of South Africa. Gold production peaked at 1,000.4 t in 1970, but has since declined steadily. The grade of ore treated in 1980 was 7.3 g per t compared with 8.2 g per t in 1979.

Of prime importance to the gold mining industry was the greater percentage of African employees working for longer periods and returning to the industry after a specific leave period. The return of experienced workers reduces the costs involved in training programs and the added costs of low productivity until the required skills are developed. A substantial increase in the workers wages over the past few years and improved social conditions at the mines are largely responsible for the improved labour situation. However, the shortage of skilled labour is acute. While the mining companies would very much like to train coloured and native African workers for semi-skilled or skilled jobs, and while the South African government probably tacitly supports this, the all-white South African Mine Worker's Union is strongly opposed and threatens strike action to shut down the entire gold mining industry if semi-skilled and skilled job categories are opened up to non-whites.

The cost of gold production in South Africa now averages about $190 per troy ounce, although costs at some mines are far higher than at others. South African mine operators are investigating possibilities for increased mechanization to increase output, but physical characteristics of the ore deposits make mechanization difficult.

South African gold production is expected to remain stable at around 650-700 tpy until 1987 and then gradually decrease.

Mining of lower grade ores in the older mines is being partially offset by expansion of production capacity.

Sales of the Krugerrand, the 1 troy ounce gold bullion coin issued by South Africa and the world leader in gold bullion coin sales, were adversely affected by the high gold price. Bullion coins are aimed at the small investor wishing to purchase gold and many of these people were not able to cope with prices in excess of $US 500. Intergold, the South African gold marketing agency, announced the issue of a series of mini-Krugerrands in denominations of 1/10, ¼ and ½ troy ounce, thus establishing a price range to accommodate various scales of investment capability.

The strong gold price has contributed to the strengthening of the South African economy and establishment of a favourable balance of payments position. It is now possible for South Africa to support the price of gold by withholding part of its output from the market at times when the price appears to be weakening.

U.S.S.R. Western observers have very little direct evidence on which to base estimates of Soviet gold production. An estimate by the CIA in 1964 of 135-155 tpy was sharply lower than any previous estimate. During the 1970s Consolidated Gold Fields conducted three separate studies of Soviet production, utilizing press reports and technical papers. The third study, still in progress, incorporates detailed study of satellite photographs of gold producing areas of the Soviet Union and further refinements of techniques used in the earlier studies. Estimated production for 1980 was in the 280-350 t range, somewhat below estimates made in previous years but higher than estimates by other Soviet-watchers who placed output at about 250 tpy. Despite the differences in production estimates, it seems clear that the Soviet Union is the world's second leading gold producer, well behind the Republic of South Africa but far ahead of the third producer, Canada.

Most Soviet gold sales in the west have been made through Zurich. Soviet sales policy is not stated but gold sales are an important source of foreign exchange. Sales in 1980 from the communist bloc were estimated at 90 t, far below the levels of previous years. The higher gold prices during 1980 may have enabled the Soviets to meet their foreign exchange requirements through smaller sales, or the heavy selling of the previous years may have somewhat depleted Soviet gold stocks.

Over two-thirds of Soviet gold production comes from the Soviet Far East and East Siberia (mainly from placers). Most of the balance comes from gold and polymetallic ores in the Urals, Kazakhstan, Armenia, Uzbekistan and West Siberia. Substantial quantities are produced as a byproduct at nonferrous operations.

Prompted by the higher international prices, the U.S.S.R. plans to increase gold production and has been importing large-scale mining equipment from western Europe, the United States, South Africa and Japan.

United States. The United States Bureau of Mines estimated gold production in the United States in 1980 to be 29 590 kg compared with 30 170 kg in 1979. About 32 per cent of the United States domestic gold production was a byproduct of base-metal mining, mainly from the copper ores in the western states. About one per cent of gold production is recovered from placer operations and the remaining 67 per cent comes from lode gold mines.

Homestake Mining Company in South Dakota is the largest lode gold producer in the United States. Kennecott Corporation, a large copper producer, was the second leading U.S. gold producer in 1980 through byproduct gold output from its Bingham Canyon mine in Utah. Carlin Gold Mining Company in Nevada is the third leading gold producer and the second largest lode gold operation. These three mines accounted for approximately two-thirds of U.S. gold output. Gold exploration in the western United States continued strong, especially in Nevada where the search was for the Carlin-type deposits, and in California where interest in placers was especially strong. A number of interesting finds have been announced and several properties are being developed for production. The most important appears to be the Jerritt Canyon deposit in Elko County, Nevada, owned by Freeport Minerals Company and FMC Corporation. Similar in type and size to the nearby Carlin deposit, Jerritt Canyon is expected to achieve production in 1982. Recovery of gold by heap leaching from low-grade deposits continues to be important in the western United States.

Canadian companies have been active in the U.S. gold mining scene. A consortium of three companies, Lacana Mining Corporation, Rayrock Mines Inc., and Siscoe Metals Inc. are developing the Pinson mine in Nevada to produce at 900 tpd in 1981. Noranda Mines Limited will develop the Grey Eagle gold-silver property in Nevada and has formed a joint venture with New Park Resources Inc. to reopen the old Mayflower mine near Park City, Utah.

The United States is a major consumer of gold, imported mainly from Canada, the U.S.S.R. and Switzerland. Most of the gold imported from Switzerland originates in the Republic of South Africa. The United States is also a major market for the South African krugerrand and the Gold Maple Leaf. In 1980 the United States was a major exporter of gold; 233 270 kg, was sent abroad, 43 per cent to Canada, 27 per cent to the United Kingdom and 12 per cent to Switzerland.

Papua-New Guinea. Papua-New Guinea is a substantial producer of gold, mainly as a byproduct of open-pit copper production at Bougainville Copper Limited. In late 1979 a feasibility study on the Ok Tedi deposit was submitted to the PNG government, which gave approval for the project in March 1980. The consortium, consisting of Dampier Mining Company Limited, Mount Fubilan Development, Kupferexploration GmbH and the PNG government, which is taking up a 20 per cent development share, will spend about $US 1000 million to bring the property into production. It will operate for the first two years as a gold mine while milling the gold-rich cap above the main copper-gold orebody. It is estimated that about 15 t/y of gold will be produced for five years.

Australia. Australian gold output in 1980 was 17 320 kg compared with 18 565 kg in 1979. Established producers mined larger tonnages of lower grade ores. In Western Australia the Marvel Loch, Comet and Haveluck mines were reopened and preparations began to reopen the Fimiston, Mt. Magnet and Lancefield mines. Exploration in all of the Australian goldfields was very active. Amateur prospectors using metal detectors had success in finding some sizeable nuggets.

Philippines. Gold production in the Philippines in 1980 was approximately 21 800 kg compared to 17 450 kg in 1979. At the end of 1980, there were seven primary producing gold mines and twelve byproduct gold producers. Two new primary gold mines and one byproduct gold producer commenced production during the year. Atlas Consolidated Mining & Development Corp. completed its Masbate gold project, the first open-pit gold mine and the second largest gold producer in the Philippines. Annual production is expected to be 2 800 kg of gold and 2 740 kg of silver.

GOLD SALES FROM OFFICIAL RESERVES

The International Monetary Fund completed its program of gold auctions in May 1980. Over the four years that the auctions were held, the Fund disposed of 25 million ounces (777.6 t), or one-sixth of its gold reserves. The gold sales raised $1.29 billion to be used for the benefit of the less developed countries. An additional 25 million ounces were restituted to member countries at 35 SDR's an ounce.

The last gold auction from the United States Treasury was in November 1979 and no further auctions are contemplated.

In December 1979, the Minister of Finance announced that Canada would sell up to one million ounces (31.1 t) of gold from its official monetary gold reserves of 22 million ounces (684.3 t). This sale was accomplished early in 1980. In August 1980 the sale of an additional million ounces of gold from the foreign exchange account was announced. Some of the gold was sold to the Royal Canadian Mint for use in the Gold Maple Leaf bullion coin program.

PRICES

The opening fixing of the London Gold Market on January 2, 1980 was $US 559 an ounce, compared to $227.15 an ounce on January 2, 1979. The price continued the steep climb that began in late 1979, peaking at $850 an ounce at the afternoon fixing on January 21, before dropping unevenly to the year's low of $474 at the morning fixing on March 18. The price then remained around the $500 range through May, when higher oil prices and increased international political tensions forced it into the $600 range. A second high of $720.50 was established on September 23 with the outbreak of war between Iraq and Iran. Despite the fact that international tensions have remained

TABLE 5. WORLD GOLD PRODUCTION, 1978-80

		(grams)	
	1978	1979P	1980^{e}
North America			
Canada	53 966 099	51 141 574	48 283 239
United States	31 066 671	30 167 421	29 589 776
Dominican Republic	10 663 041	10 978 799	11 495 762
Mexico	6 282 899	5 910 907	6 095 877
Other countries	2 731 434	2 551 223	2 699 740
Total	104 710 144	100 749 924	98 164 394
South America			
Brazil	9 358 830	10 998 020	40 433 900
Colombia	8 013 128	8 378 184	8 708 840
Peru	3 205 755	3 804 923	4 665 450
Chile	3 185 445	3 465 029	3 570 624
Other countries	2 011 182	2 216 275	3 038 918
Total	25 774 340	28 862 431	60 417 732
Europe			
U.S.S.R.	248 824 000	253 800 480	258 154 900
Spain	3 199 939	2 842 938	3 110 300
Yugoslavia	4 433 919	4 322 912	4 198 905
Sweden	2 372 972	2 177 210	2 177 210
Other countries	6 955 253	6 438 539	6 419 659
Total	265 786 083	269 582 079	274 060 974
Asia			
Philippines	18 242 873	17 450 027	21 803 203
People's Republic of China	4 665 450	6 220 600	6 998 175
North Korea	4 976 480	4 976 480	4 976 480
Japan	4 517 399	3 969 551	4 043 390
India	2 773 952	2 635 948	2 451 974
Other countries	3 537 686	3 175 958	3 314 615
Total	38 713 840	38 428 564	43 587 837
Africa			
Republic of South Africa	704 438 099	703 462 118	673 985 463
Zimbabwe	12 409 785	12 009 801	11 414 801
Ghana	12 504 463	11 259 286	12 752 230
Zaire	2 366 223	2 176 961	1 242 969
Other countries	1 244 710	918 471	1 232 052
Total	732 963 280	729 826 637	700 627 515
Oceania			
Papua-New Guinea	23 366 595	19 610 317	14 049 754
Australia	20 141 650	18 565 692	17 319 706
Fiji	872 906	956 977	867 774
Other	230 504	266 739	261 047
Total	44 611 655	39 399 725	32 498 281

Source: U.S. Bureau of Mines Minerals Yearbook 1980 Preprint **Gold.**
P Preliminary; ^{e} Estimated.

TABLE 6. AVERAGE ANNUAL PRICE OF GOLD, 1970 AND 1975-80

	London Gold Market[1] $US	equiv. $Cdn (per troy ounce)
1970	35.97	37.55
1975	161.018	163.781
1976	124.836	123.107
1977	147.718	157.089
1978	193.228	220.407
1979	306.686	359.289
1980P	612.562	716.087

[1] Annual average of London Gold Market afternoon fixing price, as reported by Sharpes Pixley Ltd.

P Preliminary.

high and that at times South Africa has tried to sustain the market by withholding some of its production, the price slid back into the $600 range in October and November and into the $500 range in December. This latest bout of price weakness was a response to record high interest rates that provided attractive alternative investment opportunities to non-interest bearing gold.

The average price for 1980, using the afternoon fixing of the London Gold Market, was $US 614.21 an ounce compared with an average of $306.70 in 1979 and $193.23 in 1978. The equivalent Canadian dollar gold price, based on the average currency exchange differential, was $716.26 compared with $359.25 an ounce in 1979 and $220.40 an ounce in 1978. Thanks to its spectacular performance in late 1979 and throughout 1980, gold has appreciated against all major currencies including the Swiss franc, the Deutschmark and the yen.

The unprecedented activity in international gold markets was at first attributed to the ratcheting upward of political tension in the Middle East, affecting what J. Aron & Company Inc. in its analysis of the international gold market refers to as the "World Anxiety Coefficient".

Many first-time investors in the gold market who bought in late 1979 or in January 1980 when the gold hysteria was at its peak were forced by the high carrying costs to sell and absorb substantial losses. These people are unlikely to again venture into the speculative gold market in the near future. Thus, while the price will continue to move in cycles as investors sell on rising prices and buy on falling prices, the amplitude of the cycles may be less extreme.

Although gold prices of recent years appear to be much higher than the $US 35 an ounce fixed price that prevailed from 1934 to 1968, and the earlier $US 20.67 an ounce price, this picture changes when inflation is taken into account and historical gold prices are converted into their equivalent prices expressed in 1979 constant dollars. On this basis, it was only in 1979 that gold prices rose above the former record prices that prevailed around 1900 and during the 1930s.

Current gold prices indicate continuing strong world demand for gold. Consumption for electronics, dental, and other industrial uses (only a fraction of which is ultimately recovered for re-use) amounts to 10 to 15 per cent of total world gold production. Much of the remaining demand is for carat jewellery, coins, medals, medallions and private sector bullion purchases. High-carat jewellery, gold coins, gold wafers and the like have been much in demand in recent years and, although this "investment" gold could be returned to circulation, much of it is purchased by individuals who have no serious intention of reselling it in the short term. Repeal of laws in the United States restricting ownership of gold by private individuals, together with today's relative affluence and the ready availability of gold wafers and gold coins at prices affordable by small investors, have resulted in a popular demand for gold that may well continue to absorb large quantities of the metal. Also, gold bullion is one of the vehicles for the investment of surplus "petrodollars" accumulated by some of the OPEC nations.

For some years the shortfall between non-communist world demand for, and production of, gold has been met from gold sales by the Soviet Union, the United States Treasury and the International Monetary Fund. Investment and speculative demand for gold seems likely to continue to exert pressure on the available gold supply for the next few years, and there may be a shortfall in the amount of gold readily available to meet world demand. Therefore, although the actions of gold speculators may cause considerable price fluctuations, it seems likely that the price of gold will continue to climb in constant dollar terms.

USES AND CONSUMPTION

Gold has traditionally been used as a monetary reserve by governments and central banks in the settlement of international balances but, since August 1971 when convertibility of the U.S. dollar into gold was suspended, it has not been officially used for this purpose. With the ratification of the Second Amendment of the Articles of Agreement, gold ceased to have an official price. It is worth noting that although gold no longer has an official price, most countries, Canada being among the very few exceptions, are maintaining or increasing the amount of gold held in their reserves.

Because it is an excellent electrical conductor, gold has many uses in the rapidly expanding electronics industry. A thin film of gold also improves the thermal properties of glass, used for architectural purposes and the cockpit windows in airliners. Research has been directed toward the development of technology leading to a more efficient use of gold, such as a thinner film in gold plating, selective and spot goldplating, and a high carat surface on a low carat base. Other precious metals, chiefly silver, platinum and palladium, can substitute for gold in many applications.

Consolidated Gold Fields estimated non-communist world consumption of gold for fabrication purposes to be 521 t in 1980, a 60 per cent decrease from 1 315 t in 1979. The jewellery industry in the developed countries consumed 270 t of gold in 1980. This was offset by remelting of carat jewellery in the developing countries amounting to 150 t. The jewellery manufacturing industry in 1980 was severely depressed as consumers demonstrate strong resistance to price increases. Manufacturers are increasing the use of lower carat metal and of gold fill, gold roll and gold plate. Gold used in the minting of official gold coins in 1980 was 179 t, compared with 290 t in 1979.

Interest in numismatic and bullion gold coins continued during 1980. Such coins are popular with small investors wishing to acquire gold but unfamiliar with bullion trading procedures. The Gold Institute/ l'Institut de l'Or reported that in 1980, 57 countries issued a total of 176 gold coins of varying gold content. The krugerrand series, the legal tender bullion gold coin of the Republic of South Africa, accounted for about 60 per cent of the gold thus consumed. One and a half million ounces were consumed in the minting of the Gold Maple Leaf.

OUTLOOK

The normal demand-supply situation that exists for other metals is less relevant to gold because of the enormous stocks in the hands of governments, investors, speculators and hoarders. The possibility of gold sales to the world market by the communist countries, chiefly the U.S.S.R., also affects the demand-supply equation. Sales from stocks and by the U.S.S.R. are difficult to predict, complicating efforts to estimate future gold prices. Another major problem encountered in forecasting gold prices is that gold has proved to be one of the few investments to retain its value in the face of rapidly increasing inflation and depreciating currencies, especially in the case of the U.S. dollar. A gold price forecast therefore depends heavily on sub-forecasts of the probable level of inflation and of the strength of the U.S. dollar over the relevant time period.

The record gold price achieved in early 1980 was not sustainable but, as the price drifted into the $US 500 range by the end of the year, some institutional investors re-entered the market as buyers. However, the feeling among analysts is that gold is in a bear market that may persist for some time. Two factors contributing to the weakness of gold have been record high interest rates in the United States, and the strength of the U.S. dollar in world markets.

Given the political philosophy of the present U.S. administration, there is virtually no possibility that the U.S. Treasury gold auctions will be resumed during its mandate. There is no indication that the International Monetary Fund is planning further sales. Private hoarders and the central banks of a number of countries that have increased their gold holdings may buy or sell as the market appears to them to be advantageous. Sales from the U.S.S.R., which were lower in 1980 than in previous years, may increase depending on how much foreign exchange the Soviets need to support the Polish economy and to make grain purchases to offset poor harvests.

World mine production of gold in 1981 will probably be little changed from 1980. Plans for expansion of existing mines and development of new mines are under way in almost all gold producing areas of the world but these ventures will have little impact on production statistics for between two and five years. Only if there were a number of major new, easily mineable gold finds such as Serra Pelada in Brazil, would world mine production be increased noticeably in a short time. If the price of gold holds firm (or increases) there is a strong possibility that gold production in 1985 will be substantially higher than at present.

The increase in the price of gold has also had an impact on the economics of base-metal production, particularly on copper. World copper prices were weak through the late 1970s and profitability of a number of producing copper mines depends on by-product gold recovery. Gold is attaining the status of coproduct in some cases. The gold content, particularly of the upper weathered portions of the orebody, is a critical factor in the development of the Dizon Mine in the Philippines and the Ok Tedi deposit in Papua-New Guinea.

Investment demand for gold during the 1980s is difficult to predict. At least temporarily, the demand triggered by the increase in the "World Anxiety Coefficient" appears to have been satisfied. Tension-creating geopolitical developments have not triggered dramatic or sustained price movements. In fabrication, the trend is to use less gold or to substitute away from gold. The speculation fever that prevailed at the beginning of 1980 has subsided and more rational prices are likely to prevail.

Gypsum and Anhydrite

D.H. STONEHOUSE

Production of gypsum has related closely to activity in the building construction sector where wallboard, the principal gypsum product, is used in both residential and non-residential buildings. There has been a trend toward the use of relatively more gypsum wallboard in institutional and commercial buildings because of its fire retardant qualities. This, together with increasing amounts being used in retrofit applications, make it inaccurate to relate wallboard requirements directly to housing starts as was once possible.

Decreasing building activity in Canada and the United States in 1980 resulted in total shipments of gypsum being reduced by about 10 per cent. Only from British Columbia and Ontario were shipments greater than in 1979; British Columbia shipments being higher in response to continued good activity in housing and in the cement industry, which also uses gypsum.

Close to 70 per cent of the crude gypsum produced in Atlantic Canada, which is Canada's principal gypsum-producing region, is shipped to company wallboard plants in the eastern United States from Canadian subsidiary operations. The remainder is shipped up the St. Lawrence River to both wallboard and cement plants. New Brunswick production is used locally, Ontario production is used on site except for that from the new Westroc Industries Limited mine at Drumbo which is shipped to its Mississauga wallboard plant. Manitoba production, and output from Windermere in British Columbia, supply the prairie and British Columbia markets. Imports from Mexico are used by both wallboard and cement producers in British Columbia.

Domtar Inc.'s new wallboard plant at Caledonia, Ontario began production during 1980, on schedule. The new plant incorporates an energy- and labour-saving, one step, grinding and calcining technique to produce stucco, which is the plaster portion of the wallboard sandwich. Domtar's long-term plans include development of a new underground mine at Caledonia.

In 1978 Domtar Inc. completed the purchase from Kaiser Gypsum Co. of two gypsum wallboard plants, one gypsum wallboard paper mill, all in California; and Kaiser's 49 per cent interest in a Mexican gypsum mine. Domtar Inc. is currently building a wallboard plant at Tacoma, Washington which, when completed in 1981, will have a capacity of 300 million square feet of board a year.

Westroc Industries Limited began producing wallboard from its new Calgary plant during the year.

Canadian Gypsum Company Limited closed down its 70-year-old Hillsborough, New Brunswick, wallboard plant on December 31, 1980, claiming the plant had been inefficient for many years and the regional market will not support a new optimum sized plant.

TABLE 1. CANADA, GYPSUM PRODUCTION AND TRADE, 1979 AND 1980

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Production (shipments)				
Crude gypsum				
Nova Scotia	5 613 347	26,385,930	4 853 000	26,435,000
Ontario	723 558	4,586,954	793 000	7,488,000
British Columbia	720 705	3,787,734	737 000	4,446,000
Newfoundland	846 812	5,198,250	650 000	4,043,000
Manitoba	134 610	857,665	134 000	1,057,000
New Brunswick	59 134	309,454	42 000	201,000
Total	8 098 166	41,125,987	7 209 000	43,670,000
Imports				
Crude gypsum				
Mexico	134 149	2,494,000	119 692	2,759,000
United States	18 154	463,000	35 023	795,000
United Kingdom	40	2,000	-	-
Hong Kong	120	1,000	-	-
Total	152 463	2,960,000	154 715	3,554,000
Plaster of paris and wall plaster				
United States	17 796	2,569,000	18 790	2,906,000
France	102	92,000	33	6,000
United Kingdom	195	50,000	25	3,000
West Germany	89	15,000	19	3,000
Other countries	48	19,000	36	7,000
Total	18 230	2,745,000	18 903	2,925,000
	(square metres)		(square metres)	
Gypsum lath, wallboard and basic products				
United States	697 894	912,000	446 856	956,000
United Kingdom	15 812	25,000	-	-
Total	713 706	937,000	446 856	956,000
Total imports gypsum and gypsum products		6,642,000		7,435,000
	(tonnes)		(tonnes)	
Exports				
Crude gypsum				
United States	5 437 532	25,703,000	4 960 214	25,671,000
Bahamas	47 233	196,000	-	-
Total	5 474 765	25,899,000	4 960 214	25,671,000

Sources: Energy, Mines and Resources Canada; Statistics Canada.

P Preliminary; - Nil.

MARKETS, TRENDS AND OUTLOOK

Because gypsum is a relatively low-cost, high-bulk mineral commodity it is generally produced from deposits situated as conveniently as possible to areas in which markets for gypsum products exist. Exceptions occur if deposits of unusually high quality are available, even at a somewhat greater distance from markets; if comparatively easy and inexpensive mining methods are applicable, or if low-cost, high-bulk shipping facilities are accessible. Nova Scotia and Newfoundland deposits meet all three of these criteria and have been operated for many years by, and for, United States companies in preference to United States deposits.

In general, gypsum products are not shipped great distances because freight and handling costs for these relatively inexpensive building materials can become excessive. Markets are usually supplied by the closest producer. There are exceptions to this situation, however, and on occasion imports of wallboard from the United States, particularly into Ontario, Alberta and British Columbia, have been significant. During the last two years these imports have been

TABLE 2. CANADA, SUMMARY OF GYPSUM MINING OPERATIONS, 1980

Company	Location	Remarks
Newfoundland		
Flintkote Holdings Limited	Flat Bay	Open-pit mining of gypsum
Nova Scotia		
Little Narrows Gypsum Company Limited	Little Narrows	Open-pit mining of gypsum and anhydrite
Georgia-Pacific Corp.		
Bestwall Gypsum Division	River Denys	Open-pit mining of gypsum
Fundy Gypsum Company Ltd.	Wentworth and Miller Creek	Open-pit mining of gypsum and anhydrite
National Gypsum (Canada) Ltd.	Milford	Open-pit mining of gypsum
Domtar Inc.	MacKay Settlement	Open-pit mining of gypsum
New Brunswick		
Canadian Gypsum Company, Limited	Hillsborough[1]	Open-pit mining of gypsum
Canada Cement Lafarge Ltd.	Havelock	Open-pit mining of gypsum used in cement manufacture
Ontario		
Canadian Gypsum Company, Limited	Hagersville	Underground mining of gypsum
Domtar Inc.	Caledonia	Underground mining of gypsum
Westroc Industries Ltd.	Drumbo	Underground mine development
Manitoba		
Domtar Inc.	Gypsumville	Open-pit mining of gypsum
Westroc Industries Ltd.	Amaranth	Open-pit mining of gypsum
British Columbia		
Western Gypsum Ltd.	Windermere	Open-pit mining of gypsum

Source: Energy, Mines and Resources Canada.

[1] Closed down December 31, 1980.

reduced greatly. In 1980 less than 5 million square feet with a total value of less than $1 million was imported. Companies well situated for export trade are shipping some products offshore.

Building construction expenditures were over $26 billion in 1980 and are expected to increase by about 11 per cent to more than $29 billion in 1981. Total construction will likely reach $54.4 billion in 1981 from just over $47 billion in 1980. Construction of homes, apartments, schools and offices will continue in the building construction sector and the need for gypsum-based building products will rise steadily. Although new construction materials are being introduced, gypsum wallboard will remain popular because of its low price, ease of installation and well-recognized insulating and fire-retarding properties. The present structure of the gypsum industry in Canada is unlikely to change greatly in the near future. Building materials plants either have

TABLE 3. CANADA, SUMMARY OF GYPSUM PRODUCTS OPERATIONS, 1980

Company	Location	Remarks
Newfoundland		
Atlantic Gypsum Ltd.	Corner Brook	Gypsum products manufacture
Nova Scotia		
Domtar Inc.	Windsor	Gypsum plaster manufacture
New Brunswick		
Canadian Gypsum Company, Limited	Hillsborough[1]	Gypsum products manufacture
Quebec		
Canadian Gypsum Co. Ltd.	Montreal	Gypsum products manufacture
Canadian Gypsum Co. Ltd.	St.-Jerome	Gypsum products manufacture
Domtar Inc.	Montreal	Gypsum products manufacture
Westroc Industries Ltd.	Ste. Catherine d'Alexandrie	Gypsum products manufacture
Ontario		
Canadian Gypsum Company, Limited	Hagersville	Gypsum products manufacture
Domtar Inc.	Caledonia	Gypsum products manufacture
Westroc Industries Ltd.	Clarkson	Gypsum products manufacture
Manitoba		
Domtar Inc.	Winnipeg	Gypsum products manufacture
Westroc Industries Ltd.	Winnipeg	Gypsum products manufacture
Saskatchewan		
Genstar Limited	Saskatoon	Gypsum products manufacture
Alberta		
Domtar Inc.	Calgary	Gypsum products manufacture
Westroc Industries Ltd.	Calgary	Gypsum products manufacture
Genstar Limited	Edmonton	Gypsum products manufacture
British Columbia		
Westroc Industries Ltd.	Vancouver	Gypsum products manufacture
Domtar Inc.	Vancouver	Gypsum products manufacture
Genstar Limited	Vancouver	Gypsum products manufacture

Source: Energy, Mines and Resources Canada.

[1] Closed down December 31, 1980.

sufficient capacities to meet the short-term, regional demand for products, or are implementing expansion programs to provide greater capacity.

TECHNOLOGY

Gypsum is a hydrous calcium sulphate ($CaSO_4 \cdot 2H_2O$) which, when calcined at temperatures ranging from 120° to 205°C, releases three-quarters of its chemically combined water. The resulting hemihydrate of calcium sulphate, commonly referred to as plaster of paris, when mixed with water, can be moulded, shaped or spread and subsequently dried, or set, to form a hard plaster product. Gypsum is the main mineral constituent in gypsum wallboard, lath and tile. Anhydrite, an anhydrous calcium sulphate ($CaSO_4$), is commonly associated geologically with gypsum.

Crude gypsum is crushed, pulverized and calcined to form stucco, which is mixed with water and aggregate (sand, vermiculite or expanded perlite) and applied over wood, metal or gypsum lath to form interior wall finishes. Gypsum board, lath and sheathing are formed by introducing a slurry of stucco, water, foam, pulp and starch between two unwinding rolls of absorbent paper, the result is a continuous "sandwich" of wet board. As the stucco hardens, the board is cut to predetermined lengths, dried, bundled and stacked for shipment.

TABLE 4. WORLD PRODUCTION OF GYPSUM, 1979 AND 1980

	1979	1980[e]
	(000 tonnes)	
United States	13 200	11 000
Canada	8 098	7 209
Iran	6 400	5 800
France	5 900	5 400
U.S.S.R.	5 400	5 000
Spain	4 500	4 200
Italy	4 200	3 800
United Kingdom	3 300	3 000
West Germany	2 300	2 100
Mexico	1 900	1 700
Other market economy countries	15 200	13 900
Other central economy countries	4 000	3 600
World total	74 400	66 700

Sources: Energy, Mines and Resources Canada; United States Bureau of Mines Mineral Commodity Summaries, January 1981.

[e] Estimated.

Keene's cement is made by converting crushed gypsum to insoluble anhydrite by calcining at temperatures as high as 700°C, usually in rotary kilns. The ground calcine, mixed with a set accelerator, produces a harder and stronger plaster product than ordinary gypsum plaster.

Crude gypsum is also used in the manufacture of portland cement where it acts as a retarder to control set. It is used as a filler in paint and paper manufacture, as a substitute for salt cake in glass manufacture and as a soil conditioner.

Byproduct gypsum, produced from the acidulation of phosphate rock in phosphate fertilizer manufacture, has not been utilized in Canada despite available technology from European countries and from Japan. In these countries, byproduct gypsum is used in the manufacture of gypsum products, by cement manufacturing plants, and also for soil stabilization. Recent studies have indicated that a potential radiation hazard

TABLE 5. CANADA, GYPSUM PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975-80

	Production[1]	Imports[2]	Exports[2]	Apparent Consumption[3]
		(tonnes)		
1970	5 732 068	35 271	4 402 843	1 364 496
1975	5 719 451	55 338	3 691 676	2 083 113
1976	6 002 154	54 770	3 798 243	2 258 681
1977	7 233 931	24 042	4 994 323	2 263 650
1978	8 074 441	70 995	5 178 631	2 966 805
1979	8 098 166	152 463	5 474 765	2 775 864
1980P	7 209 000	154 715	4 960 214	2 403 501

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Producers' shipments, crude gypsum. [2] Includes crude and ground, but not calcined. [3] Production, plus imports, minus exports.

P Preliminary.

exists in the use of phosphogypsum produced from sedimentary phosphate rock which can contain significant quantities of uranium and radium. Methods of extracting U_3O_8 from the phosphoric acid product have been devised, but removal of radium from the byproduct phosphogypsum is yet to be accomplished.

The use of lime or limestone to desulphurize stack gases from utility or industrial plants burning high-sulphur fuel will also result in production of large amounts of waste gypsum sludge, which in itself will present disposal problems if profitable uses are not developed.

Canadian Standards Association standards A 82.20 and A 82.35 relate to gypsum and gypsum products.

OCCURRENCES

Gypsum occurs in abundance throughout the world but, because its use is dependent on the building construction industry, developments are generally limited to the industrialized countries. Reserves are extremely large and are conservatively estimated at over 2 billion t. In Canada, many occurrences besides those currently being exploited are known - in the southwest lowlands, west of the Long Range Mountains in Newfoundland; throughout the central and northern mainland of Nova Scotia as well as on Cape Breton Island; in the southeastern counties of New Brunswick; on the Magdalen Islands of Quebec; in the Moose River, James Bay and southwestern regions of Ontario; in Wood Buffalo National Park, in Jasper National Park, along the Peace River between Peace Point and Little Rapids, and north of Fort Fitzgerald in Alberta; on Featherstonhaugh Creek, near Mayook, at Canal Flats, Loos, and Falkland in British Columbia; on the shores of Great Slave Lake, the Mackenzie, Great Bear and Slave rivers in the Northwest Territories; and on several Arctic islands.

The United States is the world's largest single producer of natural-gypsum and, together with Canada, brings North American production to about 30 per cent of world output.

ANHYDRITE

Production and trade statistics for anhydrite are included with gypsum statistics. Anhydrite is produced by Fundy Gypsum Company

TABLE 6. CANADA, HOUSE CONSTRUCTION, BY PROVINCE, 1979 AND 1980

	Starts			Completions			Under Construction		
	1979	1980	% Diff.	1979	1980	% Diff.	1979	1980	% Diff.
Newfoundland	2,999	3,848	+28	2,611	2 986	+14	2,850	3,736	+31
Prince Edward Island	1,068	475	-55	1,173	692	-41	403	179	+56
Nova Scotia	4,538	3,895	-14	6,132	4,512	-26	3,634	2,762	-24
New Brunswick	5,021	2,646	-47	5,090	3,258	-36	1,951	1,318	-32
Total (Atlantic Provinces)	13,626	10,864	-20	15,006	11,448	-24	8,838	7,995	-10
Quebec	41,730	29,186	-30	44,288	33,560	-24	20,413	14,639	-28
Ontario	56,887	40,127	-29	76,570	54,021	-29	44,851	31,187	-30
Manitoba	5,772	2,597	-55	8,410	4,503	-46	4,992	2,694	-46
Saskatchewan	11,742	6,250	-47	10,865	7,763	-29	8,640	6,022	-30
Alberta	39,947	32,031	-20	44,492	34,717	-22	25,454	20,378	-20
Total (Prairie Provinces)	57,461	40,878	-29	63,767	46,983	-26	39,086	29,094	-26
British Columbia	27,345	37,546	+37	26,858	30,156	+12	15,413	22,865	+48
Total Canada	197,049	158,601	-20	226,489	176,168	-22	128,601	105,780	-18

Source: Statistics Canada.

Limited at Wentworth, Nova Scotia, and by Little Narrows Gypsum Company Limited at Little Narrows, Nova Scotia. According to the **Nova Scotia Annual Report on Mines 1980,** production of anhydrite in that year was 191 439 t. Most of this was shipped to the United States for use in portland cement manufacture and as a peanut crop fertilizer. Cement plants in Quebec and Ontario also used some Nova Scotia anhydrite.

TABLE 7. CANADA, VALUE OF CONSTRUCTION[1] BY TYPE, 1979-81

	1979	1980	1981
		($ million)	
Building construction			
Residential	14 267	13 776	15 417
Industrial	2 068	2 565	2 845
Commercial	5 074	6 011	6 870
Institutional	1 831	2 108	2 314
Other building	1 466	1 663	1 743
Total	24 706	26 123	29 189
Engineering construction			
Marine	235	256	331
Highways, airport runways	3 380	3 510	3 730
Waterworks, sewage systems	1 863	2 000	2 251
Dams, irrigation	174	202	247
Electric power	4 279	4 110	4 802
Railway, telephones	1 621	1 891	2 073
Gas and oil facilities	4 643	6 326	8 320
Other engineering	2 122	2 651	3 475
Total	18 317	20 946	25 229
Total construction	43 023	47 069	54 418

Source: Statistics Canada.

[1] Actual expenditures 1979, preliminary actual 1980, intentions 1981.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
29200-1	Gypsum, crude	free	free	free	free
29300-1	Plaster of paris, or gypsum, calcined, and prepared wall plaster, weight of package to be included in weight for duty; per hundred pounds	free	5.8¢	12.5¢	free
29400-1	Gypsum, ground, not calcined	free	free	15%	free
28410-1	Gypsum tile	14.3%	14.3%	25%	9.5%

MFN Reductions under GATT (effective January 1 of year given)

	1980	1981	1982	1983	1984	1985	1986	1987
29300-1	5.8¢	5.5¢	5.3¢	5.0¢	4.8¢	4.5¢	4.3¢	4.0¢
28410-1	14.3%	13.6%	12.8%	12.1%	11.4%	10.7%	9.9%	9.2%

TARIFFS (Cont'd.)

UNITED STATES (MFN)			British Preferential		Most Favoured Nation		General	General Preferential	
Item No.									
512.21	Gypsum crude				free				
		1980	1981	1982	1983	1984	1985	1986	1987
512.24	Gypsum, ground calcined, per ton	57¢	55¢	53¢	50¢	48¢	46¢	44¢	42¢
245.70	Gypsum or plastic building boards and lath, ad valorem	5.6%	5.1%	4.7%	4.2%	3.8%	3.3%	2.9%	2.4%

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated 1980, USITC Publication 1011; U.S. Federal Register, Vol. 44, No. 241.

Iron Ore

M.A. BOUCHER

Canadian iron ore shipments declined from 59.6 million tonnes (t) in 1979 to 50.8 million t in 1980. The reduction in shipments was the result of depressed demand for steel in the United States and the European Economic Community (EEC) countries.

Steel production in the United States, which is Canada's major market for iron ore, decreased 18 per cent to 100.8 million t. A corresponding fall in iron ore requirements at U.S. steel mills caused Canadian exports to that market to decrease from 22.8 million t in 1979 to 17.2 million t in 1980.

In the EEC countries, Canada's second-largest market for iron ore, steel production decreased almost 9 per cent to 128 million t and Canadian exports to that market decreased from 19.4 million t in 1979 to 16.6 million t in 1980.

Steel production in Canada decreased 1.1 per cent to 15.9 million t in 1980; consequently, domestic consumption of iron ore decreased from 17.2 million t to 16.6 million t in the year.

The Lake Erie base price for iron ore pellets was increased 8.7 per cent and for Mesabi non-Bessemer ore almost 16 per cent during 1980. World prices of iron ore increased 15 to 20 per cent during the year.

CANADIAN DEVELOPMENTS

The Quebec-Labrador producers operated at normal levels until June, 1980 when two of the companies announced plans to close their facilities for an extended period during summer vacation time.

Iron Ore Company of Canada (IOC) suspended one pellet line at Sept Iles in June and the second line in August. One pellet line resumed production in September and remained in operation for the balance of the year. Also, IOC's Carol Lake operations were closed for five weeks beginning in mid-July, and mining at Schefferville was suspended in mid-September, about one month earlier than normal.

Wabush Mines suspended mining and pelletizing operations for one month beginning July 1. Elsewhere in the region, Quebec Cartier Mining Company (QCM) operated near normal levels until the fall, when it became clear that shipments in 1980 would be below earlier forecasts. The company reduced production accordingly and reassigned underemployed personnel to repairs, maintenance and development. Sidbec-Normines Inc, in the process of breaking in a new mine-concentrator-pellet plant facility, increased production to near the annual capacity rate of 6 million t of pellets. However, the company curtailed

TABLE 1. CANADA, IRON ORE PRODUCTION AND TRADE, 1979 AND 1980

	1979		1980^{p}	
	(tonnes)[1]	($)	(tonnes)[1]	($)
Production (mine shipments)				
Newfoundland	30 219 792	963,943,018	26 194 000	939,938,000
Quebec	20 854 529	543,256,717	17 447 000	506,916,000
Ontario	7 874 939	287,190,991	6 524 000	262,578,000
British Columbia	668 026	13,008,475	701 000	13,380,000
Total[2]	59 617 286	1,807,399,201	50 866 000	1,722,812,000
Imports				
Iron ore				
United States	5 051 107	199,716,000	5 652 845	262,490,000
Brazil	791 681	25,482,000	221 994	7,418,000
Sweden	45 477	1,509,000	-	-
Norway	23 970	673,000	-	-
Bolivia	346	11,000	-	-
Total	5 912 581	227,391,000	5 874 839	269,908,000
Exports				
Iron ore, direct shipping				
United States	3 413 136	48,539,000	2 792 820	51,253,000
Italy	447 518	6,379,000	445 235	8,362,000
Belgium and Luxembourg	194 350	2,774,000	133 955	2,478,000
West Germany	36 596	522,000	-	-
Total	4 091 600	58,214,000	3 372 010	62,093,000
Iron ore, concentrates				
Netherlands	4 985 150	85,574,000	5 205 228	109,509,000
United States	3 918 356	102,735,000	3 712 627	107,438,000
Japan	4 721 512	72,682,000	3 806 838	73,677,000
United Kingdom	4 188 569	77,625,000	1 833 355	38,781,000
France	1 322 050	21,941,000	1 653 077	35,146,000
Italy	1 762 772	30,150,000	1 296 786	26,816,000
West Germany	1 703 401	29,732,000	1 226 879	26,423,000
Yugoslavia	200 404	3,676,000	411 820	9,135,000
Belgium and Luxembourg	539 218	12,311,000	328 264	7,366,000
Austria	-	-	180 301	3,933,000
Philippines	309 478	4,024,000	202 894	3,195,000
Portugal	120 480	2,979,000	97 262	3,116,000
Other countries	388 476	7,153,000	167 085	3,935,000
Total	24 159 866	450,582,000	20 122 416	448,470,000
Iron ore, agglomerated				
United States	15 460 525	629,077,000	10 723 961	507,184,000
United Kingdom	1 995 235	85,552,000	1 853 975	85,593,000
West Germany	478 874	21,143,000	1 031 576	49,477,000
Netherlands	1 555 782	65,060,000	1 005 913	48,921,000
Italy	263 509	9,633,000	311 211	13,064,000
Japan	-	-	181 508	7,477,000
Other countries	779 232	33,085,000	384 573	17,580,000
Total	20 533 157	843,550,000	15 492 717	729,296,000

TABLE 1. (cont'd.)

	1979		1980[P]	
	(tonnes)[1]	($)	(tonnes)[1]	($)
Iron ore, nes				
United States	64 296	1,686,000	6 934	305,000
United Kingdom	63	27,000	-	-
Argentina	288	26,000	-	-
Total	64 647	1,739,000	6 934	305,000
Total exports, all classes				
United States	22 856 313	782,037,000	17 236 342	666,180,000
Netherlands	6 540 931	150,634,000	6 211 141	158,430,000
United Kingdom	6 183 867	163,204,000	3 687 330	124,374,000
Japan	4 721 513	72,682,000	3 988 346	81,154,000
West Germany	2 218 871	51,397,000	2 258 455	75,900,000
Italy	2 473 799	46,162,000	2 053 232	48,242,000
France	1 322 050	21,941,000	1 786 469	41,308,000
Belgium and Luxembourg	901 764	22,238,000	581 807	15,462,000
Yugoslavia	228 908	4,893,000	511 827	13,664,000
Other countries	1 401 254	38,897,000	679 128	15,450,000
Total	48 849 270	1,354,085,000	38 994 077	1,240,164,000
Consumption of iron ore at Canadian iron and steel plants	17 189 502	..	16 574 155	..

Sources: Energy, Mines and Resources Canada; Statistics Canada; American Iron Ore Association.

[1] Dry tonnes for production (shipments) by province; wet tonnes for imports and exports.
[2] Total iron ore shipments include shipments of byproduct iron ore.
[P] Preliminary; - Nil; .. Not available; nes Not elsewhere specified.

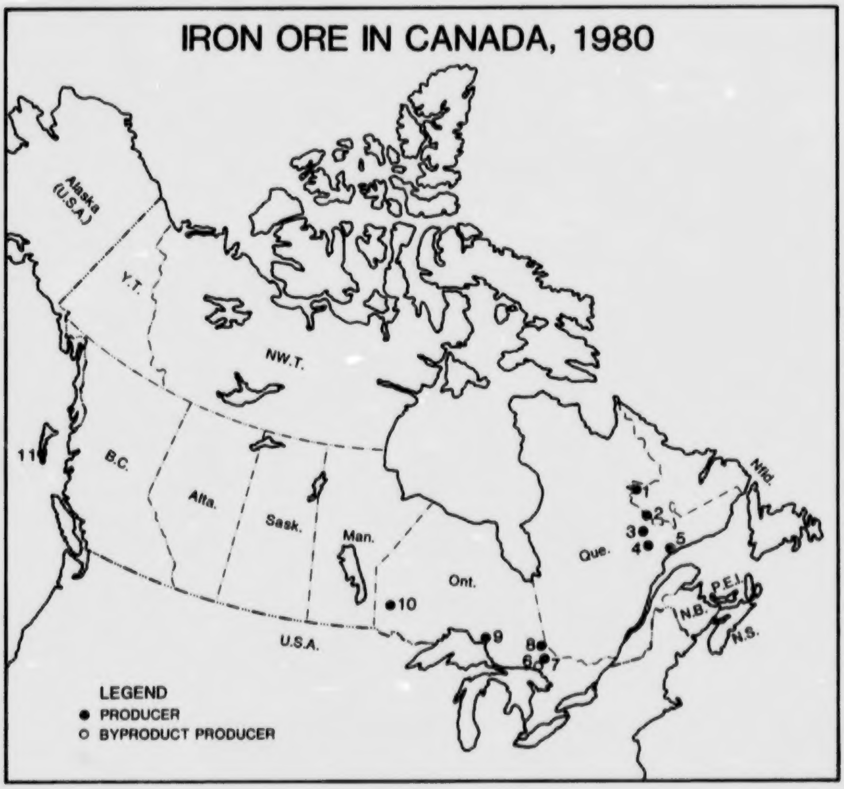
production at one of its two pellet lines on December 1 and operated with one line for the remainder of 1980.

A severe ice storm in December, 1980 caused extensive damage to power lines in the North Shore area. Pellet production at Wabush Mines was suspended for about two weeks and Quebec Cartier's port was idle for one week because of the resulting power interruption.

Iron ore production in Ontario continued to decline, with the termination of production at two pellet plants. Caland Ore Company Limited near Atikokan had closed its mine in November, 1979 and suspended pellet production in April, 1980. All assets were disposed of by end of year. Altogether, some 400 jobs were lost at Caland. Pellet production at Inco Limited (Inco), Sudbury, Ontario was suspended for an indefinite period in June 1980 because of depressed markets. Inco, a producer of byproduct iron ore from Sudbury nickel-copper ores, had accumulated approximately one full year of pellet production in unsold stocks. This plant suspension resulted in the loss of about 90 jobs.

Craigmont Mines Limited, a British Columbia copper producer that recovers a magnetite concentrate as byproduct, announced that it would continue mining into early 1981. The mine was originally slated for closure in 1979 because of depleted ore reserves, but higher copper prices have allowed the company to use lower-grade ore and thereby extend the life of the mine. The company produces 40 000 to 50 000 tpy of magnetite concentrate.

Due to depressed iron ore markets and excess production capacity worldwide, reports of new Canadian iron ore developments have all but ceased. However, one proposal to develop a 10 million tpy iron ore mine on the Melville Peninsula, NWT was



IRON ORE IN CANADA, 1980

Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
1
2
3
4
5
6
7
8
9
10
11
LEGEND
● PRODUCER
○ BYPRODUCT PRODUCER

Producers
(numbers refer to numbers on map above)

1. Iron Ore Company of Canada, Knob Lake Division (Schefferville)
2. Iron Ore Company of Canada, Carol Division (Labrador City)
2. Scully Mine of Wabush Mines (Wabush)
3. Quebec Cartier Mining Company (Mount Wright)
4. Sidbec Normines Inc. (Gagnon, Fire Lake)
5. Iron Ore Company of Canada, Sept-Iles Division (Sept-Iles)
5. Wabush Mines, Pointe Noire Division (Pointe Noire)
5. Quebec Cartier Mining Company and Sidbec Normines Inc. (Port Cartier)
7. Sherman Mine of Dofasco Inc. (Temagami)
8. Adams Mine of Dofasco Inc. (Kirkland Lake)
9. Algoma Ore Division of The Algoma Steel Corporation, Limited (Wawa)
10. The Griffith Mine (Bruce Lake)
11. Wesfrob Mines Limited (Moresby Is.)

Byproduct producers

6. Inco Limited (Copper Cliff)

TABLE 2. CANADA, IRON ORE PRODUCTION (SHIPMENTS), 1978-80

Company and Location	Ore Mined	Product Shipped	1978	1979	1980
			(000 tonnes, natural wt)		
Adams Mine, Kirkland Lake, Ont.	Magnetite	Pellets	1 250	1 242	1 213
Algoma Ore Division of The Algoma Steel Corp. Ltd., Wawa, Ont.	Siderite	Sinter	1 732	1 711	1 548
Caland Ore Co. Ltd., Atikokan, Ont.	Hematite and goethite	Pellets	957	832	534
		Concentrates	546	303	639
Griffith Mine, Bruce Lake, Ont.	Magnetite	Pellets	1 553	1 530	1 520
Iron Ore Company of Canada, Schefferville, Que.	Hematite, goethite and limonite	Direct shipping	3 007	4 087	3 251
Carol Lake, Lab.	Specular hematite and magnetite	Concentrate	3 898	8 363	6 963
		Pellets	6 755	10 649	8 430
Sept Iles, Que.	Schefferville "treat ore"	Pellets	3 597	4 731	2 808
Marmoraton Mining Co. Ltd., Marmora, Ont.	Magnetite	Pellets	137	-	-
National Steel Corporation, Capreol, Ont.	Magnetite	Pellets	655	231	-
Quebec Cartier Mining Company, Mount Wright, Que.	Specular hematite	Concentrate	9 911	14 809	11 975
Sidbec-Normines Inc. Fire Lake and Lac Jeannine, and Port Cartier, Que.	Specular hematite	Concentrate	248	100	95
		Pellets (standard)	1 164	3 358	2 915
		Pellets (low silica)	344	731	1 385
Sherman Mine, Temagami, Ont.	Magnetite	Pellets	1 155	947	1 110
Steep Rock Iron Mines Ltd., Atikokan, Ont.	Hematite	Pellets	1 302	985	-
Wabush Mines, Wabush, Labrador and Pointe Noire, Que.	Specular hematite and magnetite	Pellets	4 419	5 539	4 855
Wesfrob Mines Limited, Queen Charlotte Islands, B.C.	Magnetite	Pellet feed	610	588	611
		Fine magnetite	-	-	24

TABLE 2. (cont'd)

Company and Location	Ore Mined	Product Shipped	1978	1979	1980
			(000 tonnes, natural wt)		
Byproduct producer					
Inco Limited					
Sudbury, Ont.	Pyrrhotite	Pellets	361	135	51
Total			43 601	60 871	49 927

Source: Energy, Mines and Resources Canada.
- Nil.

announced in June 1980 by Borealis Exploration Limited. The company reported that a new mine could be in production by 1985.

The third of a three-phase toll increase on the St Lawrence Seaway was effected in 1980. This represented a 13 cents/t increase in Seaway toll charges for iron ore shipped from Sept Iles to Lake Erie. However, the toll increases since 1978 are relatively small compared with recent changes in Great Lakes shipping rates.

As a result of lower iron ore shipments in Canada, traffic of iron ore on the Seaway and at Great Lakes ports (Sept Iles, Port Cartier, Pointe Noire, Little Current, Depot Harbour, Thunder Bay) decreased from 17.4 million t in 1979 to 13.3 million t in 1980.

A government-industry technical task force on major problems faced by the iron ore industry met once during 1980. Work in 1980 centred on sampling and analyzing waste water as part of the program to find a process method that can eliminate the coloured waste-water problem.

FOREIGN DEVELOPMENTS

The recent increase in pellet plant capacity worldwide, combined with rising fuel oil costs and soft markets, resulted in the temporary suspension of production at many pellet plants around the world. In the United States, National Steel Corporation suspended operations at its Keewatin, Minnesota plant, and The Hanna Mining Company closed its Butler plant at Nashwauk and the Erie plant at Hoyt Lakes, Minnesota. Many of the U.S. plants were scheduled to resume production in early 1981.

Production of iron ore pellets in Australia fell from 9.3 million t in 1979 to approximately 5 million t in 1980 due to closures at Hamersley's Dampier Mining Company Limited plant in February and Cliffs Robe River Iron Associates Lambert plant at the end of April. Fuel cost increases made production uneconomic at prevailing pellet prices. Total pellet capacity in Australia is 12 million tpy. Of this, Hamersley and Robe River represent two-thirds of capacity.

The Norwegian state-owned company, Sydvaranger A/S of Kirkenes suspended all production at its iron ore and pellet operations for an indefinite time because of large unsold stocks and soft markets in Europe.

TABLE 3. PRODUCTION AND CAPACITY OF PIG IRON AND CRUDE STEEL AT CANADIAN IRON AND STEEL PLANTS, 1979 AND 1980

	1979	1980P
	(tonnes)	
Pig iron		
Production	10 905 660	10 892 628
Capacity at December 31[1]	11 730 000	11 797 000
Steel ingots and castings		
Production	16 078 041	15 901 243
Capacity at December 31	18 947 040	20 407 440

Source: Statistics Canada.
[1] In blast or in use.
P Preliminary.

TABLE 4. RECEIPTS, CONSUMPTION AND STOCKS OF IRON ORE AT CANADIAN IRON AND STEEL PLANTS, 1979 AND 1980

	1979	1980P
	(tonnes)	
Receipts imported	5 988 042[1]	6 074 120[2]
Receipts from domestic sources	12 260 251[3]	11 429 416[4]
Total receipts at iron and steel plants	18 248 293	17 503 536
Consumption of iron ore	17 189 502[5]	16 574 155[6]
Stocks of ore at docks, plants and mines, December 31	..	14 535 031

Source: American Iron Ore Association.
[1] Compared with 5 912 581 t in Table 1. [2] Compared with 5 874 839 t in Table 1. [3] Compared with domestic shipments of 12 140 335 t compiled by Statistics Canada. [4] Compared with 11 436 356 t compiled by Statistics Canada. [5] Compared with 16 410 124 t compiled by Statistics Canada for blast furnace consumption. [6] Compared with 15 760 181 t compiled by Statistics Canada for blast furnace consumption.
P Preliminary; .. Not available.

The Brazilian government gave its approval in 1980 for Cia Vale do Rio Doce (CVRD) to proceed with development of the huge Carajas project. The project, calling for capacity of 35 million tpy of iron ore and requiring the construction of a 890 km railroad is scheduled to be in production by 1985. CVRD is expected to raise 40 per cent of the estimated $3.2 billion capital cost, while other financial institutions such as the Brazilian Development Bank and the World Bank will be approached to provide loans for the balance. Japanese steel companies were reported to be negotiating with CVRD on a long-term ore purchase contract. Other countries interested in purchasing Carajas iron ore include West Germany, Italy and France.

The United States Department of Justice ended its antitrust investigations on pricing practices in the iron ore industry in April, 1980. This investigation was part of the "Shared Monopoly Investigation" initiated by Justice in 1977. The action on the iron ore industry was terminated because of lack of evidence to show that antitrust laws had been violated.

A recent study[1] by AMAX Iron Ore Corporation, with major iron ore holdings in Australia, indicates that the present surplus "supply" of iron ore in the world could be brought in balance with demand in 1982-83. However, more recent evidence suggests that the surplus will likely be extended to 1984-85. Steel production in the United States, the EEC and Japan is growing at a much lower rate than expected and the growth rate is unlikely to change substantially during the next two to three years. The authors of the AMAX study note that a serious shortage could develop in the mid- to late-1980s if prices of iron ore do not increase sufficiently to allow for new expansions and the development of new projects. According to the report, three or four major new projects (10 to 25 million tpy each) would be required to supply additional demand for iron ore in the western world in 1990. AMAX, using ranking criteria with emphasis on high-grade ore with good blast furnace and sintering properties and large and easily mineable reserves allowing future expansions and low operating costs, concluded that Carajas in Brazil and one of the large projects under discussion in Australia, such as Marandoo or Goldsworthy, are likely to be the first two projects for development. Other possible projects include Mifergui Nimba Co. in Guinea, Kudremukh Iron Ore Co. Ltd. in India, Mekambo in Gabon and Wologisi in Liberia.

DIRECT REDUCTION

World production of sponge iron in 1980 was 7.12 million t, while total installed capacity was 20 million t. Table 7 shows sponge iron production by process.

A recent forecast by Institut de Recherches de la Sidérurgie Française (IRSID)[2] indicates that sponge iron production capacity could reach 40 million t in 1985 and 60 million t in 1990. The countries most

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[1] **Iron Ore Availability - The Need for New Development** by W.W. Bilhorn and R.E. Sargent. Paper presented at the 2nd International Iron Ore Symposium in Frankfurt, West Germany, March 1981.
[2] **The Growing Importance of Direct Reduction in the Iron Ore Business** by J. Astier, President of Societé Française de Minerais Préréduits, and Director, IRSID. Paper presented at the 2nd International Iron Ore Symposium in Frankfurt, West Germany, March 1981.

TABLE 5. CANADIAN CONSUMPTION OF IRON-BEARING MATERIALS BY INTEGRATED[1] IRON AND STEEL PRODUCERS, 1980

Material Consumed	Sinter Plants at Steel Mill	Direct Reduction Plants	Consumed In Iron and Steel Furnaces: Production of Pig Iron	Steel Furnaces	Total in Furnaces
			(tonnes)		
Iron ore					
Crude and concentrate	185 429	-	102 228	7 558	109 786
Pellets	120 380	1 316 964	13 075 528	90 777	13 166 305
Sinter	135 022	-	1 415 939	-	1 415 939
Sinter produced at steel plant	-	-	1 158 313	-	1 158 313
Direct-reduced iron	237 785	-	107 242	743 566	850 808
Other iron-bearing materials					
Flue dust	29 978	-	-	-	-
Mill scale, cinder, slag	141 887	-	95 472	3 502	98 974

Source: Company data.

[1] Dofasco Inc.; Sidbec-Dosco Limited; Sydney Steel Corporation; The Algoma Steel Corporation, Limited; Stelco Inc.

- Nil.

TABLE 6. WORLD IRON ORE PRODUCTION, 1978-80

	1978	1979P	1980e
	(000 tonnes)		
U.S.S.R.	246 251	241 738	244 999
Brazil	84 985	104 083	105 994
Australia	83 134	91 716	95 542
People's Republic of Chinae	70 006	74 984	74 984
United States	82 892	87 091	70 730
Canada (mine shipments)	42 931	59 617	50 866
India	42 598	38 837	39 534
France	33 453	31 626	28 980
Sweden	21 486	26 619	27 184
Republic of South Africa	24 206	29 565	26 313
Liberia	17 989	18 345	17 379
Venezuela	13 515	16 349	16 102
Spain	8 580	8 826	8 992
Mauritania	6 934	9 373	8 600
Chile	7 042	7 526	8 586
Mexico	5 644	6 414	8 076
North Koreae	7 112	7 417	8 027
Peru	4 922	5 444	5 730
Other countries	46 265	45 654	43 146
Total	849 945	911 224	889 764

Sources: Energy, Mines and Resources Canada; U.S. Bureau of Mines.

P Preliminary; e Estimated.

TABLE 7. SPONGE IRON PRODUCTION BY PROCESS

Process	World Production, 1980	Share of World Production
	(million t)	(%)
Midrex	3.96	55
Hyl	2.36	33
SL/RN	0.23	3
Fior	0.23	3
Armco	0.21	3
Codir	0.12	2
Accar	0.01	1
Total	7.12	100

Source: **Skillings Mining Review**, May 9, 1981.

likely to build direct reduction (D-R) plants in the future are those that possess large and low-cost reserves of natural gas or oil. Such countries include Mexico, Venezuela, Peru, Trinidad, Saudi Arabia, Libya and Nigeria.

A major development in 1980 included the start-up of the Midrex plant owned by the Iron and Steel Company of Trinidad and Tobago (Iscott).

Sidbec remained the only producer of sponge iron in Canada in 1980, primarily because scrap prices were low in Canada during most of the year. Production at Sidbec in 1980 was close to the annual capacity of 1.2 million t.

PRICES

The Lake Erie base price for pellets was increased once during 1980, from US 66.7 cents an iron tonne unit to 72.5 cents, effective January 31, 1980. Mesabi non-Bessemer iron ore was quoted at $US 24.21 per t at the beginning of 1980 and was increased to $US 28.05 at mid-year, where it remained for the rest of 1980.

Contrecoeur (Sidbec) direct-reduced iron pellets were increased in price from $US 115 per t to $US 130 about mid-1980 and remained at this price quotation for the balance of 1980.

During 1980 the composite price for No. 1 heavy melting steel scrap reached a high of $US 107 per t in February, up from $US 95 in January, decreased to a low of $US 68 in June, and then increased to about $US 100 late in the year.

The contracted price of iron ore products on international markets increased considerably in 1980. Most contracts called for increases of 15 to 20 per cent above 1979 prices.

OUTLOOK

The iron ore industry is not expected to show much improvement in 1981 compared with 1980. Weak markets combined with excess production capacity worldwide will probably hold Canadian mine output at a level slightly lower than in 1980. While the Lake Erie base price will likely be adjusted upwards in parallel with rising energy, materials, transportation and labour costs, the international price for iron ore is not expected to increase significantly.

Iron ore markets should begin to improve about late-1981. However, record high interest rates that emerged in late-1980 in North America will have a severe dampening effect on capital investment projects and consumer spending for durables. If high interest rates persist through 1981, a recovery in iron ore markets might be delayed until 1982. The North American situation

TABLE 8. CANADA, IMPORTS OF STEEL SCRAP BY PROVINCE, 1978-80

		1978		1979		1980^{P}	
		World	U.S.	World	U.S	World	U.S.
Nova Scotia	tonnes	152	152	-	-	175	175
	$000	9	9	-	-	17	17
New Brunswick	tonnes	434	434	1 442	1 442	640	640
	$000	43	43	116	116	92	92
Quebec	tonnes	64 267	64 263	52 313	52 309	56 641	56 628
	$000	3,336	3,296	5,187	5,187	4,361	4,359
Ontario	tonnes	277 606	277 399	343 721	343 099	362 487	362 478
	$000	17,857	17,792	31,862	31,814	31,019	31,015
Manitoba	tonnes	85 981	85 981	90 222	90 222	56 385	56 385
	$000	4,730	4,730	8,271	8,271	3,823	3,823
Saskatchewan	tonnes	155 407	155 407	177 626	177 626	146 801	146 801
	$000	9,690	9,690	16,950	16,950	14,579	14,579
Alberta	tonnes	81 864	81 864	69 510	69 510	41 682	41 682
	$000	3,722	3,722	6,096	6,096	4,317	4,317
British Columbia	tonnes	2 272	2 249	2 677	1 908	2 999	2 669
	$000	158	156	256	204	300	276
Canada Total	tonnes	667 983	667 749	737 511	736 116	667 810	667 458
	$000	39,545	39,438	68,738	68,638	58,508	58,478

Source: Statistics Canada.
P Preliminary; - Nil.

is unlikely to be counter-balanced by other major markets, as slow economic growth is anticipated in western European countries and Japan.

The longer-term outlook continues to be dominated by the spectre of under-utilized world production capacity, particularly with regard to pellet plants. Viewed in this perspective, Canadian mine output is forecast to increase at a very slow and erratic rate, and no major mine development can be foreseen before the mid- to late-1980s.

TABLE 9. CANADA, EXPORTS OF STEEL SCRAP, BY PROVINCE OF LADING, 1978-80

		1978		1979		1980P	
		World	U.S.	World	U.S.	World	U.S.
Newfoundland	tonnes	168	168	-	-	-	-
	$000	16	16	-	-	-	-
Nova Scotia	tonnes	940	486	133	64	209	59
	$000	196	107	64	17	44	12
New Brunswick	tonnes	118	118	46	3	405	357
	$000	13	13	10	...	34	21
Quebec	tonnes	225 949	18 195	299 499	14 543	264 903	7 904
	$000	16,479	1,480	38,830	1,713	33,979	997
Ontario	tonnes	381 756	349 908	402 257	378 022	241 332	231 740
	$000	28,334	23,874	35,594	32,587	26,398	24,983
Manitoba	tonnes	2 761	2 761	9 940	9 866	6 924	6 887
	$000	346	346	1,412	1,399	1,243	1,237
Saskatchewan	tonnes	18	18	699	699	2 080	2 080
	$000	8	8	154	153	290	290
Alberta	tonnes	1 524	1 504	5 317	5 153	793	793
	$000	121	118	581	537	99	99
British Columbia	tonnes	94 930	92 282	139 354	134 532	116 583	110 443
	$000	6,889	6,487	12,210	11,570	13,936	12,951
Yukon	tonnes	-	-	-	-	-	-
	$000	-	-	-	-	-	-
Canada Total	tonnes	708 164	465 440	857 245	542 882	633 229	360 263
	$000	52,402	32,449	88,855	47,976	76,023	40,590

Source: Statistics Canada.
P Preliminary; - Nil; ... Less than $500.

TABLE 10. LAKE ERIE BASE PRICE OF SELECTED ORES AT YEAR-END, 1970 AND 1975-80

	1970	1975	1976	1977	1978	1979	1980
				($US)			
Mesabi Non-Bessemer (per tonne)[1]	10.63	18.21	19.94	20.84	21.95	24.21	28.05
Old Range Non-Bessemer (per tonne)[1]	10.87	18.45	20.19	21.09	22.19	24.46	28.30
Pellets (per tonne natural iron unit)[2]	0.262	0.464	0.523	0.546	0.599	0.667	0.725

Sources: **Skillings Mining Review; Iron Age.**
[1] 51.5 per cent of iron natural, at rail of vessel, lower lake ports. [2] One iron unit equals 1 per cent of a tonne; For example, 60 per cent iron ore has 60 units.

TABLE 11: SELECTED PRICES OF IRON ORE BOUND FOR JAPAN AND EUROPE 1976-80
(US cents per Fe Unit DMT, FOB)

Ore	Market	Company	%Fe	1976	1977	1978	1979	1980
Fines (including concentrate)	Europe	Rio Doce	(64)	22.7	23.0	21.5	23.5	28.1
		Iscor	(65)	23.0	22.3	20.6	22.4	26.9
		Kiruna	(66)	28.2	27.3	23.6	26.6	34.5
		Carol Lake		-	-	-	23.7	29.3
		Mt. Wright	(66)	-	25.0	22.5	24.0	29.75
	Japan	Rio Doce		17.4	19.8	19.7	21.6	25.4
		Iscor		17.9	17.9	18.5	21.6	25.0
		Hamersley		17.4	20.3	20.9	22.7	27.6
		Carol Lake	(65)	-	-	21.2	21.4	25.1
Lump	Europe	Rio Doce		25.9	24.9	22.6	26.6	31.2
		Iscor	(65)	30.0	28.3	23.7	25.5	31.9
	Japan	Rio Doce		20.6	20.8	20.3	21.6	25.4
		Iscor	(65)	22.4	22.4	23.0	24.7	28.6
		Hamersley		21.5	25.6	24.3	25.7	31.2
Pellets	Europe	Rio Doce		43.8	42.8	36.4	40.2	47.1
		Kiruna		47.4	45.5	38.0	42.2	49.9
	Japan	Rio Doce (Nibrasco)		-	-	-	46.0	50.3
		Savage River		-	-	-	37.9	46.2

Sources: **The Tex Report, Metal Bulletin** and **Japan Commerce Daily.**
- Not available; DMT dry metric tonne; FOB free on board.

Iron and Steel

C.J. CAJKA

OVERVIEW

The production of crude steel in Canada declined 1.1 per cent in 1980 to 15.9 million tonnes (t), down from 16.1 million t in 1979. Producer shipments of rolled steel products increased 0.5 per cent from 12.2 million t in 1979 to 12.3 million t. However, apparent domestic consumption of rolled steel declined 12.8 per cent from 11.9 million t to 10.4 million t. The overall small increase in producer shipments was due to a substantial growth in steel mill exports, which increased 70.2 per cent from 1.6 million t in 1979 to 2.7 million t in 1980, and some import displacement as steel imports declined 31.8 per cent from 2.2 million t to 1.5 million t.

World crude steel production decreased 4.0 per cent in 1980 to 717.7 million t from 747.2 million t in 1979. While the centrally planned economies reported a slight increase in production, many of the western countries had significantly reduced output compared to the year earlier. In particular, the United States showed a decline of just over 18 per cent from 123.3 million t in 1979 to 100.8 million t in 1980. Japan, with a steel production of 111.5 million t in 1980, displaced the United States as the second-largest producer in the world, while the U.S.S.R. with a production of 152.0 million t ranked in first place. Japanese steel production in 1980 was essentially identical to the previous year's output. Steel output in the European Economic Community (EEC) declined by 8.9 per cent to 127.8 million t in 1980. Several of the developing countries continued to show increases in production.

On June 1, 1980 the first steel was cast at Stelco Inc.'s greenfield project, the Lake Erie Works at Nanticoke, Ontario. This complex represents the largest steel project ever undertaken in Canada and the only fully integrated steel mill to be built in North America in many years.

Several other major expansion programs were completed by the Canadian steel industry during 1980. Interprovincial Steel and Pipe Corporation Ltd. (IPSCO) initiated production on a new 80-inch hot rolling mill at its Regina, Saskatchewan plant. Dominion Bridge Company, Limited increased mill capacity to 250 000 t of bar and structural sections at its Manitoba rolling mills. Lake Ontario Steel Company Limited (Lasco) was completing a $100 million expansion project at Whitby, Ontario at year-end 1980 and thereby doubling rolling capacity to 853 000 t.

In addition to the projects completed in 1980, the Canadian steel industry had many major renovation and expansion programs either under construction or in a planning stage. The Algoma Steel Corporation, Limited announced plans for a $120 million coke-oven battery and a $300 million seamless tube mill. IPSCO started work on a $50 million tubular goods centre in Calgary, Alberta. Dofasco Inc. had under construction a fourth galvanizing line and had plans for a $450 million hot strip mill. Atlas Steels, a division of Rio Algom Limited, was in the midst of a long-range $100 million program to modernize its Welland, Ontario plant. At L'Orignal, Ontario Ivaco Rolling Mills Division of Ivaco Inc. was in the

TABLE 1. CANADA, GENERAL STATISTICS OF THE DOMESTIC PRIMARY IRON AND STEEL INDUSTRY, 1978-80

	UNIT	1978	1979	1980P
Production				
Volume indexes				
Total industrial production	1971=100	129.0^r	135.0	132.8
Iron and steel mills[1]	1971=100	135.3^r	144.2	145.8
Value of shipments, iron and steel mills[1]	$ million	4,959.6^r	5,945.1	6,398.9
Value of unfilled orders, year-end, iron and steel mills	$ million	821.4^r	958.4	935.9
Value of inventory owned, year-end, iron and steel mills	$ million	1,156.0^r	1,497.7	1,548.8
Employment, iron and steel mills[1]				
Administrative	number	11,159	11,775	12,547
Hourly rated	number	41,549	44,084	45,204
Total		52,708	55,859	57,751
Employment index, all employees	1961=100	152.8	161.9	166.5
Average hours per week, hourly rated	number	39.9	40.1	39.7
Average earnings per week, hourly rated	$	333.89	365.46	392.10
Average salaries and wages per week, all employees	$	350.81	383.71	413.37
Expenditures, iron and steel mills[1]				
Capital: on construction	$ million	52.5	60.1	85.6
on machinery	$ million	257.0	310.0	493.9
Total	$ million	309.5	370.1	579.5
Repair: on construction	$ million	36.3	47.3	42.1
on machinery	$ million	471.3	583.3	700.5
Total	$ million	507.6	630.6	742.6
Total capital and repair	$ million	817.1	1,000.7	1,322.1
Trade, primary iron and steel[2]				
Exports	$ million	1,271.1^r	1,444.9	1,879.7
Imports	$ million	974.9^r	1,483.8	1,241.4

Source: Statistics Canada; Compiled by Energy, Mines and Resources Canada.

[1] S.I.C. Class 291 - Iron and Steel Mills: covers the production of pig iron, steel ingots, steel castings, and primary rolled products, sheet, strip, plate, etc. [2] Includes pig iron, steel ingots, steel castings, semis, hot and cold-rolled products, pipe, wire and forgings. Excludes sponge iron, iron castings.

^{P} Preliminary; ^{r} Revised.

process of making several improvements to its steel-making and rolling facilities.

Stelco Inc. and IPSCO signed contracts in 1980 with Foothills Pipe Lines (Yukon) Ltd. for the supply of large diameter pipe for the Alaska Highway natural gas pipeline. The first shipments began in late-1980. More than 1.1 million t of pipe could be committed for pipeline construction during the life of the contracts.

In November, 1980 a committee consisting of representatives from Sydney Steel Corporation (Sysco), the federal government and the Nova Scotia government proposed a three-phase, $351.5 million 10-year business plan for the restructuring of the Sysco steel mill at Sydney, Nova Scotia.

The United States trigger price mechanism (TPM) was suspended in the first quarter of 1980. Later in the year as the U.S. steel industry slipped further into recession, the President of the United States approved a comprehensive steel program including, among other measures, the reimposition of the trigger price mechanism.

The steel market in the European Community continued to be reasonably strong in early-1980. However, by early summer steel demand weakened considerably and the European Community Commission took action to have producers reduce shipments voluntarily. This approach had limited success and on October 31, 1980 the commission imposed mandatory crude steel production quotas.

CANADIAN PRODUCTION, SHIPMENTS AND CONSUMPTION

Canadian pig iron capacity decreased slightly in 1980 to 11.7 million t from 11.8 million t in 1979. Blast furnaces accounted for 95 per cent of this total and electric furnaces for the remainder. The production of pig iron totalled 10.9 million t in 1980, which was approximately the same amount as in 1979. Blast furnaces produced 91 per cent of total pig iron output. Producer shipments of pig iron increased to 783 261 t in 1980 compared to 405 384 t in 1979.

Steelmaking capacity, which was 18.6 million t in 1979, increased to 18.9 million t in 1980. Basic oxygen converters accounted for 54.5 per cent, open-hearth furnaces for 19.7 per cent and electric furnaces for 25.8 per cent. Crude steel production including steel castings totalled 15 901 243 t in 1980, compared to 16 078 041 t in 1979, a slight decrease of 1.1 per cent. Basic oxygen furnace production declined 344 246 t or 3.8 per cent, open-hearth furnace production declined 44 260 t or 1.3 per cent, while electric furnace production increased 217 795 t or 6.3 per cent. The output of steel castings, produced mainly by electric furnaces, decreased 16 087 t, or 2.7 per cent, to 217 266 t.

Average steel furnace capacity utilization decreased from 86.4 per cent in 1979 to 83.9 per cent in 1980. Basic open hearth furnaces had the highest utilization rate at 86.9 per cent, followed by basic oxygen furnaces at 84.9 per cent and electric furnaces at 82.3 per cent. Capacity utilization of steel castings furnaces increased slightly from 49.5 per cent in 1979 to 51.1 per cent in 1980.

Steelmaking furnaces consumed 10.0 million t of pig iron in 1980, a 3.0 per cent reduction from 1979, while ferrous scrap consumption in steelmaking furnaces increased by 2.8 per cent to 8.4 million t.

Producer shipments of steel, including steel casting and rolled steel products, increased 0.5 per cent in 1980 to 12 492 912 t, compared to 12 429 462 t in 1979. Substantial improvements were recorded for producer shipments of ingots, rails, track material and concrete-reinforcing bars. However, these strong sales were largely offset by weak markets for structural shapes, other hot rolled bars, hot and cold rolled sheet and strip, and cold finished bars.

The domestic demand for rolled steel products in 1980 was very strong at the beginning of the year, weakened considerably by the end of the second quarter and recovered again by the fourth quarter. While total domestic shipments declined 10 per cent to 9 556 614 t in 1980, the impact of the decline on different sectors was uneven. Continuing strength in natural resources and extractive industries, commercial transportation and oil country activity resulted in expanded markets for steel in these sectors. Producer deliveries for ship building increased to 42 781 t (an increase of 47.4 per cent from 1979), railway operating to 302 340 t (+9.7%), natural resources and extractive industries to 263 871 t (+3.9%) and pipes and tubes to 1 654 919 t (+3.1%). Depressed markets in the automotive, agriculture and other

TABLE 2. CANADA, PIG IRON PRODUCTION, SHIPMENTS, TRADE AND CONSUMPTION, 1978-80

	1978	1979	1980P
		(tonnes)	
Furnace capacity January 1[1]			
Blast	10 304 000	11 240 019	11 190 000
Electric	567 000	566 990	540 000
Total	10 871 000	11 807 009	11 730 000
Production			
Basic iron	9 512 985	10 400 732	10 015 698
Foundry iron[2]	825 281	504 928	876 930
Total	10 338 266	10 905 660	10 892 628
Shipments	684 439	405 384	783 261
Imports			
Tonnes	2 555	9 913	2 076
Value ($000)	521	2 130	513
Exports			
Tonnes	544 716	255 523	562 348
Value ($000)	92 150	47 874	110 994
Consumption of pig iron			
Steel furnaces	9 346 645	10 275 058	9 966 585
Consumption of iron and steel scrap			
Steel furnaces	7 698 640	8 167 315	8 398 681

Sources: Statistics Canada: **Primary Iron and Steel** (monthly); **Iron and Steel Mills** (annual).

[1] The capacity figures as of January 1 in each year take into account both new capacity and obsolete capacity anticipated for the year. [2] Includes malleable iron.

P Preliminary.

consumer goods sectors resulted in substantial declines in deliveries of steel to these markets. Steel deliveries for automotive vehicles and parts declined tol 145 932 t (a reduction of 32.0% from 1979), agriculture equipment to 160 033 t (-28.5%), metal building systems to 68 455 t (-21.7%), contractor products 558 705 t (-14.0%) and machinery and tools to 333 764 t (-12.5%). In addition, inventories were reduced as interest rates moved on an upward trend and, partly because of this factor, wholesalers, warehouses and steel service centres reduced their domestic receipts to 1 781 122 t, a decline of 10.7 per cent compared to 1979.

INVESTMENT AND CORPORATE DEVELOPMENTS

Expenditures in 1980 by the Canadian steel industry for capital and repairs increased 32.1 per cent to $1,322.1 million. Capital expenditures increased 56.6 per cent to $579.5 million while repair expenditures of $742.6 million increased by 17.8 per cent.

Stelco Inc., after six years of construction, began production of steel at its Lake Erie Works (LEW), Nanticoke, Ontario. Pig iron production began in May and the first steel was poured on June 1, 1980. The

TABLE 3. CANADA, CRUDE STEEL PRODUCTION, SHIPMENTS, TRADE AND CONSUMPTION, 1978-80

	1978	1979	1980P
	(tonnes)		
Furnace capacity, January 1[1]			
Steel ingot			
Basic open-hearth	3 742 137	3 742 137	3 742 250
Basic oxygen converter	9 568 985	10 185 870	10 329 900
Electric	4 222 038	4 228 388	4 449 500
Total	17 533 160	18 156 395	18 521 650
Steel castings	450 327	451 234	425 390
Total furnace capacity	17 983 487	18 607 629	18 947 040
Production			
Steel ingot			
Basic open-hearth	3 029 062	3 295 093	3 250 833
Basic oxygen	8 413 641	9 115 530	8 771 284
Electric	3 285 253	3 444 065	3 661 860
Total	14 727 956	15 854 688	15 683 977
Continuously cast, included in total above	3 011 054	3 192 286	4 072 921
Steel castings[2]	170 493	223 353	217 266
Total steel production	14 898 449	16 078 041	15 901 243
Alloy steel in total	1 850 088	2 184 057	1 974 564
Shipments from plants			
Steel castings	157 231	199 746	198 095
Rolled steel products	11 692 504	12 229 716	12 294 817
Total	11 849 735	12 429 462	12 492 912
Steel ingots included with rolled steel products above	609 555	500 176	813 763
	(000 tonnes)		
Exports, equivalent steel ingots	2 883.5^r	2 767.1	3 838.3
Imports, equivalent steel ingots	1 631.6^r	2 324.2	1 432.9
Indicated consumption, equivalent steel ingots	13 646.5^r	15 635.1	13 495.8

Source: Statistics Canada.
[1] The capacity figures as of January 1 in each year take into account both new capacity and obsolete capacity anticipated for the year. [2] Produced mainly from electric furnaces.
P Preliminary; ^{r} Revised.

main facilities put into service included a 4 764 tpd blast furnace, two 225 t basic oxygen furnaces and a twin-strand continuous caster that can produce slabs up to 1 880 mm wide, 254 mm thick and 12.2 m long. Construction was under way to complete coke ovens and a hot strip mill in 1981 and 1983 respectively. The coke-oven battery will consist of 45 coke ovens and is designed to have an annual capacity of 522 000 t. Annual steelmaking capacity at LEW is 1.17 million t. As LEW was in a start-up stage during 1980 and operated for only the last half of the year, the complex produced 272 000 t of crude steel.

Dofasco Inc. is well into a $1 billion expansion program that will allow its annual capacity to increase to 4.1 million t of crude steel by the mid-1980s. During 1980, the company relined two of its four blast furnaces and had under construction a second hot strip mill and a fourth galvanizing line. The hot strip mill, costing approximately $450 million, initially will have a design capacity of 1.1 million t and is expected to begin production in 1983. The new galvanizing line, costing $49 million, will increase the company's production capacity for galvanized products by 35 per cent, to 771 000 t.

The Algoma Steel Corporation, Limited relined two blast furnaces and modified and improved the rail and structural mill in 1980. New projects for 1981 include a plate heat-treating facility, an iron desulphurization unit, dust collecting and filtering equipment at the sinter plant, further improvements to the rail and structural mill and a slab reheating furnace and coil box in the plate and strip mill. Also, the company announced in 1980 that it will construct a $300 million seamless tube mill, scheduled for completion in 1984, and a $120 million coke-oven battery to replace two obsolete batteries.

IPSCO has completed Phase I of its $80 million expansion program. The new 80-inch hot rolling mill will permit the production of wider coils of increased thickness, with qualities suitable for sour gas and high impact (Arctic grade) steels required by pipe customers. Wider coil results in significant savings during the production of spiral welded pipe. The recently completed desulphurizing station utilizes an advanced method for controlled removal of sulphur from molten steel. Desulphurization currently takes place in the ladle, resulting in increased productivity of electric furnaces as compared to the former practice of desulphurizing in the electric furnace prior to tapping. Phase II of the expansion program will be completed in April, 1981 and will comprise the addition of a fifth electric furnace, additional soaking pits and expansion of pipe making capacity at both the Regina and Edmonton pipe mills. As a result of the expansion program, IPSCO's crude steel capacity will expand by 190 000 tpy to 680 000 tpy and the hot-rolling mill capacity will increase to 817 000 t.

In November 1980, IPSCO announced plans for the construction of a $50 million pipe plant in Calgary to produce oil- and gas-well casing. The construction of the 200 000 tpy plant is to be completed in the second half of 1982. IPSCO is also building a $1 million research centre in Regina, Saskatchewan, with completion set for April, 1981.

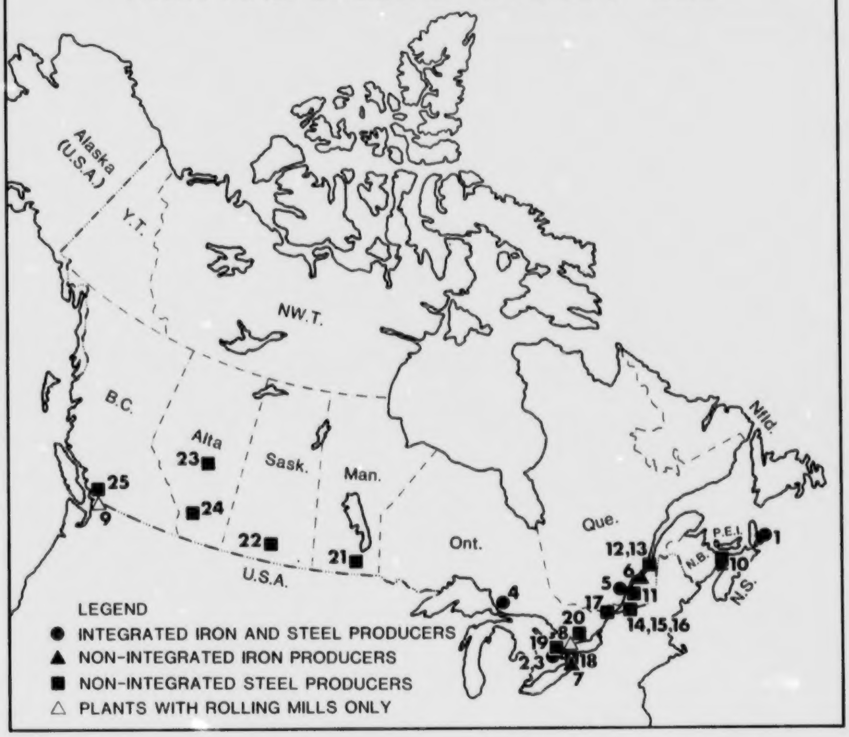
TABLE 4. PRODUCER SHIPMENTS[1] OF ROLLED STEEL[2], 1979 and 1980

	1979	1980	Growth
	(000 tonnes)		(%)
Ingots and semis	500.2	813.8	+ 62.7
Rails	345.6	782.6	+126.4
Wire rods	1 141.1	1 236.8	+ 8.4
Structural shapes	1 043.3	577.4	- 44.7
Concrete reinforcing bar	529.9	765.0	+ 44.4
Other hot-rolled bars	1 219.0	1 002.7	- 17.7
Track material	71.7	79.2	+ 10.5
Plate	1 700.7	1 773.3	+ 4.3
Hot-rolled sheet and strip	2 556.9	2 319.8	- 9.3
Cold finished bars	118.6	98.2	- 17.2
Cold reduced sheet, strip other and coated	1 936.6	1 848.8	- 4.5
Galvanized sheet	1 066.1	997.2	- 6.5
Total	12 229.7	12 294.8	+ 0.5
Alloy steel in total shipments	1 062.5	926.4	- 12.8

Source: Statistics Canada: **Primary Iron and Steel** (monthly).

[1] Includes producer exports. [2] Includes ingots and semis, but not steel castings; comprises both carbon and alloy steels.

IRON AND STEEL IN CANADA, 1980


Alaska (U.S.A.)
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N.W.T.
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Alta
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LEGEND
● INTEGRATED IRON AND STEEL PRODUCERS
▲ NON-INTEGRATED IRON PRODUCERS
■ NON-INTEGRATED STEEL PRODUCERS
△ PLANTS WITH ROLLING MILLS ONLY

Integrated iron and steel producers

(numbers refer to locations on map above)

1. Sydney Steel Corporation (Sydney)
2. Dofasco Inc. (Hamilton)
3. Stelco Inc. (Hamilton and Nanticoke)
4. The Algoma Steel Corporation, Limited (Sault Ste. Marie)
5. Sidbec-Dosco Limited (Contrecoeur)

Non-integrated iron producers

6. QIT-Fer et Titane Inc. (Sorel)
7. Canadian Furnace Division of Algoma (Port Colborne)

Plants with rolling mills only

8. Stanley Strip Steel Division of Stanley Precision, Inc. (Hamilton)
9. Pacific Continuous Steel Limited (Delta)

Non-integrated steel producers

10. Enheat Inc. (Amherst)
11. Stelco Inc. (Contrecoeur)
12. Atlas Steels a Division of Rio Algom Limited (Tracy)
13. Colt Industries (Canada) Ltd. (Sorel)
14. Canadian Steel Foundries Division of Hawker Siddeley Canada Inc. (Montreal)
15. Canadian Steel Wheel Limited (Montreal)
16. Sidbec-Dosco Limited (Montreal and Longueuil)
17. Ivaco Rolling Mills Division of Ivaco Inc. (L'Orignal)
18. Atlas Steels a Division of Rio Algom Limited (Welland)
19. Burlington Steel Division of Slater Steel Industries Limited (Hamilton)
20. Lake Ontario Steel Company Limited (Whitby)
21. Manitoba Rolling Mills Division of Dominion Bridge Company, Limited (Selkirk)
22. Interprovincial Steel and Pipe Corporation Ltd. (Regina)
23. Stelco Inc. (Edmonton)
24. Western Canada Steel Limited (Calgary)
25. Western Canada Steel Limited (Vancouver)

TABLE 5. DISPOSITION OF ROLLED STEEL PRODUCTS[1], 1979 AND 1980

	1979	1980	Growth 1979/1980
	(tonnes)		(%)
Wholesalers, warehouses and steel service centres	1 994 139	1 781 122	-10.7
Automotive vehicles and parts	1 685 991	1 145 932	-32.0
Agricultural equipment	223 803	160 033	-28.5
Contractors products	601 888	515 705	-14.3
Metal building systems	87 472	68 455	-21.7
Structural steel fabricators	1 029 588	1 035 590	+0.6
Containers	627 030	606 928	-3.2
Machinery and tools	381 434	333 764	-12.5
Wire, wire products and fasteners	859 332	771 257	-10.3
Natural resources and extractive industries	253 907	263 871	+3.9
Appliances and utensils	157 359	138 553	-12.0
Stamping, pressing and coating	532 945	487 054	-8.6
Railway operating	275 494	302 340	+9.7
Railroad cars and locomotives	228 260	195 058	-14.6
Shipbuilding	29 020	42 781	+47.4
Pipes and tubes	1 605 259	1 654 919	+3.1
Miscellaneous	47 697	53 252	+11.6
Total domestic shipments	10 620 618	9 556 614	-10.0
Producer exports[2]	1 609 098	2 738 203	+70.2
Total producer shipments	12 229 716	12 294 817	+0.5

Sources: Statistics Canada; **Primary Iron and Steel** (monthly).
[1] Includes ingots and semis, but excludes steel castings, pipe and wire. [2] Total rolled steel exports amounted to 2.132 and 3.020 million tonnes in 1979 and 1980, respectively.

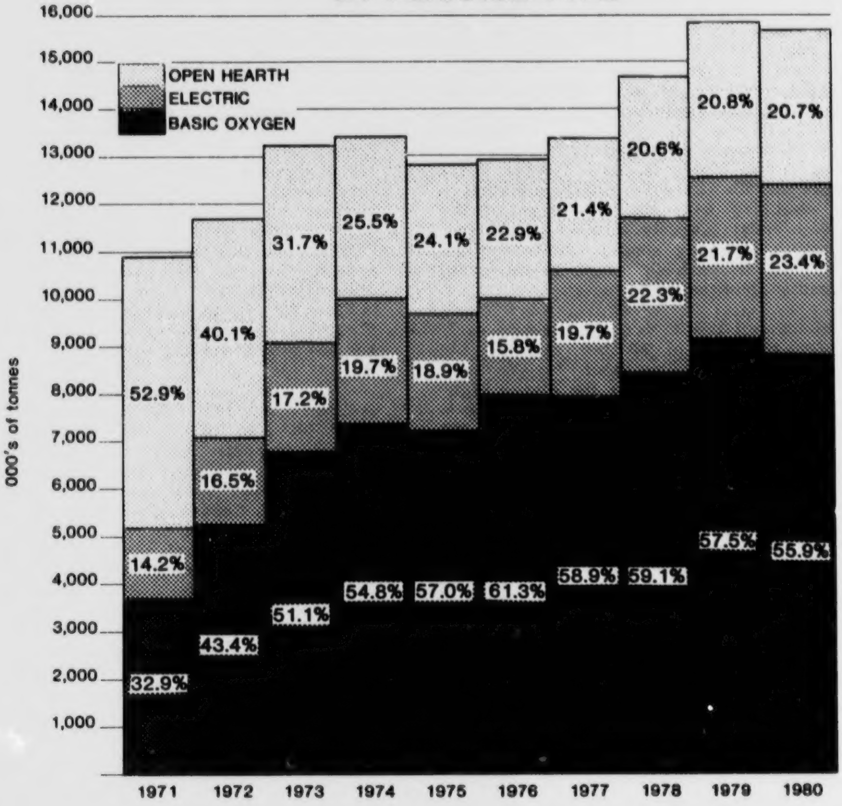
Western Canada Steel Limited made steady progress in 1980 on a modernizing program at the Vancouver, British Columbia steel plant. The company was installing a new continuous-casting machine, which was expected to be ready for operation during the first half of 1981, and a continuous rolling mill which was scheduled for start-up in 1982. When construction is completed, rolling capacity at the Vancouver mill will be increased to 158 750 t. Crude steel production capacity at the Calgary, Alberta steel mill was increased more than 30 per cent to 85 275 t in 1980 by replacement of the 20 t electric furnace with a 30 t unit.

Manitoba Rolling Mills Division of Dominion Bridge Company, Limited has completed an improvement program that was started in 1979. Capacity at the renovated facilities has been increased by 20 per cent to 226 800 tpy of bar and structural sections. The company purchased billets during the period when the melt shop was closed because of renovations.

Atlas Steels, a division of Rio Algom Limited, has undertaken a $100 million, 10-year modernization program at its Welland, Ontario steel plant. During 1980 Atlas Steels completed a $4.1 million facility to purify and recycle plant cooling water and commenced construction of a $11 million expansion of the heat treating and cold bar finishing installations. The latter should be completed by mid-1982. Operations resumed in January, 1980 at the Tracy, Quebec plant after the settlement of a nine-month strike.

Lake Ontario Steel Company Limited (Lasco) of Whitby, Ontario had nearly completed an expansion program to double annual steelmaking capacity to 907 000 t. The $100 million project, which was started in 1979, includes a new 17-stand bar mill, a reheat furnace, warehouse and shipping

CANADA PRODUCTION OF STEEL BY FURNACE TYPE



facilities, a 118 t electric furnace and a casting plant.

Stanley Strip Steel Division of Stanley Precision, Inc. of Hamilton, Ontario began production from a new $15 million hot strip mill in the fourth quarter of 1980. This six-high, highly automated precision mill has an annual capacity of 59 000 t and is the first of its kind in North America. The annual rolling capacity at the plant was increased to 90 700 t by this addition.

Several improvements were under way at Ivaco's steel mill in L'Orignal, Ontario. These include the addition of water cooled panels and roofs to both electric furnaces, the addition of four horizontal-vertical pre-finishing stands, a new tundish exchange system and the expansion of the scrap bay area.

Representatives of Sydney Steel Corporation (Sysco), the Nova Scotia Government and the federal Department of Regional and Economic Expansion (DREE) proposed a $351 million, 10-year renovation program for the Sysco steel mill at Sydney, Nova Scotia. The first phase of the proposed three-phase plan would cost $171.5 million and involve renovations to reduce production costs and improve existing facilities. These would include rebuilding both coke-oven batteries, relining one blast furnace, rebuilding two open-hearth furnaces and making improvements to the rolling mill. During Phase II, which would begin in 1987 and cost $180 million, basic oxygen steelmaking furnaces would be installed. Phase III would begin in 1990 and relate to facilities for new products.

Steel imports continued to be monitored by the federal government. However, the strength of the Canadian steel industry in 1980, combined with the low value of the Canadian dollar, largely eliminated concerns of dumping for many steel products and the emphasis has since been placed on improving the quality of import documentation.

Stelco and IPSCO won contracts in early 1980 for delivery of 80 per cent of the large-diameter pipe required by Foothills Pipe Lines (Yukon) Ltd. for the Alaska Highway natural gas pipeline. Stelco is committed to provide 617 000 t and IPSCO 505 000 t over a period of six years. The first shipments were made in late-1980. Both companies have an opportunity to bid on an additional quantity of approximately 300 000 t of pipe, the remaining 20 per cent of the total amount required for the pipeline project.

PRICES

The Lake Erie base price of iron ore pellets increased 8.6 per cent during 1980, from US66.7 cents an iron tonne unit to 72.5 cents, due to higher costs of labour, energy and transportation.

Scrap prices, as in previous years, moved within a broad range during 1980; the composite price for No. 1 heavy melting steel scrap increased to $US 107 per t in February, 1980 from $95 per t in January, decreased to a low of $68 per t in June, and then increased to approximately $100 per t late in the year.

Prices for steel mill products increased an average of 9.9 per cent in 1980, reflecting the increased costs of labour, energy and raw materials.

Table 15 shows prices for several raw materials used by the steel industry and for selected steel products in 1979 and 1980.

TRADE

Canadian exports of steel products showed unusual strength in 1980, due in large part to the devaluation of the Canadian dollar relative to most other currencies. Imports, on the other hand, decreased because of reduced domestic demand for steel products and the depreciation of the Canadian dollar, making the cost of imported products relatively expensive.

Domestic producer exports of rolled steel products increased by 70.2 per cent from 1 609 098 t in 1979 to 2 738 203 t in 1980, whereas total Canadian steel exports rose from 2 711 800 t to 3 558 200 t, an increase of 31.2 per cent. Exports to the United States were virtually unchanged from 1979 at approximately 2.2 million t, whereas exports to the European Coal and Steel Community (ECSC) increased from 143 000 t to 226 200 t; to Japan, from 6 200 t to 49 000 t; and to other countries from 314 400 t to 1 054 000 t.

Canadian imports of steel products declined in 1980 to 1 519 600 t from 2 211 300 t in 1979, a decrease of 31.3 per cent. Imports from all countries were lower, with the exception of Japan, from where Japanese suppliers shipped marginally more steel to Canada in 1980 than in 1979.

No serious problems arose for Canadian steel exporters during 1980 because of the United States TPM. Most Canadian steel entered the United States market under pre-clearance provisions that allow for prices less than the trigger price. The United States government planned to announce a new schedule of pre-clearance conditions and product coverage in early 1981. A further concern of Canadian exporters was the proliferation of "Buy American" state laws. Such laws could have a substantial negative impact on Canadian exports and could become a serious deterrent to export unless this trend reverses.

During 1980, the European Economic Community (EEC) concluded bilateral agreements with several countries to limit steel exports to the EEC. Canada was not approached to enter into such an agreement.

WORLD REVIEW

In 1980, crude steel production in the world decreased 4.0 per cent to 717.7 million t, down from the record 747.2 million t reported in 1979. The leading producer was the U.S.S.R. at 152.0 million t, an increase of 2 per cent over 1979. United States production fell to 100.8 million t, a decrease of

TABLE 6. CANADA, TRADE IN STEEL BY PRODUCT[1], 1978-80

	Imports			Exports		
	1978^r	1979	1980P	1978^r	1979	1980P
	(000 tonnes)					
1. Steel castings (including grinding balls)	16.1	16.0	16.3	23.4	34.7	14.2
2. Ingots	37.4	72.2	94.8	34.2	20.0	65.3
3. Semi-finished steel blooms, billets, slabs	17.2	108.0	9.9	245.3	100.8	261.3
4. Total (1+2+3)	70.7	196.2	121.0	302.9	155.5	340.8
5. Finished steel						
A) Hot-rolled						
Rails	22.6	15.9	23.8	178.0	221.5	240.3
Wire rods	190.4	166.3	106.5	312.9	360.8	541.8
Structurals	151.5	276.2	209.2	323.9	334.0	299.4
Bars	110.1	113.9	66.9	137.3	154.8	290.5
Track material	5.0	4.7	5.9	17.5	11.6	13.4
Plate	288.6	439.3	247.5	275.2	303.5	340.0
Sheet and strip	183.5	284.0	170.9	259.8	218.9	417.1
Total hot-rolled	951.7	1 300.3	830.7	1 504.6	1 605.1	2 142.5
B) Cold-rolled						
Bars	18.0	20.5	16.2	13.6	11.3	15.3
Sheet and strip	67.2	76.1	29.1	86.1	57.4	135.9
Galvanized	53.2	89.2	31.2	192.4	148.7	166.0
Other[1]	111.8	152.5	103.0	190.4	188.4	233.4
Total cold-rolled	250.2	338.3	179.5	482.5	405.8	550.6
6. Total finished steel (A+B)	1 201.9	1 638.6	1 010.2	1 987.1	2 010.9	2 693.1
7. Total rolled steel (2+3+6)	1 256.5	1 818.8	1 114.9	2 266.6	2 131.7	3 019.7
8. Total steel (4+6)	1 272.6	1 834.8	1 131.2	2 290.0	2 166.4	3 033.9
9. Total steel (raw steel equivalent)[2]	1 631.6	2 324.2	1 432.9	2 883.5	2 767.1	3 838.3
10. Fabricated steel products						
Steel forgings	9.3	9.5	9.1	40.7	45.8	40.6
Pipe	317.0	284.9	326.7	374.9	415.5	388.7
Wire	72.2	82.2	52.6	84.5	84.1	94.9
11. Total fabricated	398.5	376.6	388.4	500.1	545.4	524.2
12. Total castings, rolled steel and fabricated (8+11)	1 671.1	2 211.4	1 519.6	2 790.1	2 711.8	3 558.1

Source: Statistics Canada.
[1] Includes steel for porcelain enameling, terneplate, tinplate and silicon steel sheet and strip. [2] Calculation: finished steel (row 6) divided by 0.77, plus steel castings, ingots and semis (row 4).
P Preliminary; ^{r} Revised.

18.3 per cent from the 123.3 million t reported in 1979. The United States slipped in rank during 1980 to third-largest producer, after Japan, which had a production of 111.5 million t, virtually unchanged from the previous year. Production in the EEC declined 8.9 per cent in 1980 to 127.8 million t. Most EEC countries showed a decrease of between 4 and 10 per cent, although France's output was essentially unchanged and United Kingdom crude steel production fell drastically by 46.5 per cent to 11.5 million t, largely due to a major strike in the U.K. steel industry early in the year. Production continued to expand in many of the developing countries of Latin America, Asia and the Middle East.

The TPM remained in effect during the first quarter of 1980 in the United States until steel companies petitioned the government to take anti-dumping action.

TABLE 7. CANADA, VALUE[1] OF TRADE IN STEEL CASTINGS, INGOTS, ROLLED AND FABRICATED PRODUCTS, 1978-80

	Imports			Exports		
	1978r	1979	1980P	1978r	1979	1980P
			($000)			
Steel castings	18,465	33,627	41,707	19,714	32,685	16,148
Steel forgings	20,796	33,160	48,139	60,682	75,200	69,775
Steel ingots	7,190	19,200	24,560	5,862	4,562	14,627
Rolled products						
Semis	8,913	39,562	9,573	52,024	26,145	71,628
Other	591,263	962,754	696,012	763,325	904,046	1,209,608
Fabricated						
Pipe and tube	267,607	310,707	357,805	216,124	283,778	302,625
Wire	60,101	82,627	63,042	61,204	70,584	84,340
Total steel	974,335	1,481,637	1,240,838	1,178,935	1,397,000	1,768,751

Source: Statistics Canada.

[1] The values in this table correspond with the tonnages shown in Table 6.

P Preliminary; r Revised.

TABLE 8. CANADA, TRADE IN STEEL[1] BY COUNTRY, 1978-80

	Imports			Exports		
	1978r	1979	1980P	1978r	1979	1980P
			(000 tonnes)			
United States	612.0	914.8	623.1	2 212.5	2 248.2	2 229.0
ECSC[2] countries	447.0	622.3	275.1	110.3	143.0	226.1
Japan	380.1	365.3	373.1	0.2	6.2	49.0
Other	232.0	309.0	248.3	467.1	314.4	1 054.0
Total	1 671.1	2 211.4	1 519.6	2 790.1	2 711.8	3 558.1

Source: Statistics Canada.

[1] Comprised of steel castings, ingots, semis, finished steel, forgings, pipe and wire.

[2] European Coal and Steel Community (Belgium, Denmark, France, Ireland, Italy, Luxembourg, Netherlands, United Kingdom, West Germany).

P Preliminary; r Revised.

During the second quarter of the year the steel market in the United States deteriorated rapidly and reached a low point in July when the American industry slowed to 51.7 per cent of rated production capacity. On September 30, 1980, President Carter announced a program to aid the industry. This included, among other measures, the reintroduction of the TPM for a period from three to five years, beginning with the fourth quarter of 1980. The price levels for imports under the TPM were set approximately 12 per cent higher than those for the first quarter of 1980.

The revived TPM allows for further analysis of the import situation if the domestic industry is operating at below 87 per cent of capacity utilization, imports increase to over 13.7 per cent of apparent domestic consumption, and there appears to be a surge in imports of one or more specific products from one or more specific countries. Appropriate action will be taken if it appears that the TPM is being evaded. If imports exceed 15.2 per cent of apparent consumption, and the Department of Commerce determines that unfair competition is occurring as the result of dumping or subsidization, the Department will initiate action to establish countervailing or dumping duties on a specific country or on a product line basis. The TPM will not be suspended under these provisions.

The TPM will be terminated at the end of three years if the Secretary of Commerce finds that the domestic steel industry modernization program is moving at an inadequate pace. The Administration also has proposed changes in the tax depreciation schedule and an extension of the time-frame to meet air pollution standards in an effort to accelerate capital formation, needed by the steel companies for modernization of existing facilities. It is expected that the U.S. industry will have completed its modernization program at the end of the five-year period and the TPM will then be suspended.

Steel markets in the western European countries lagged the U.S. downward pattern that developed in early-1980, although European markets showed definite signs of weakness by the summer months. In July 1980, the EEC Commission attempted to have the production of steel by EEC steel producers curtailed voluntarily. However, this approach had limited success in bringing order to the chaotic production and market conditions.

On October 31, the EEC Commission declared a state of manifest crisis in steel and imposed mandatory crude steel production quotas until June, 1981. EEC quotas for the fourth quarter of 1980 imposed production cuts from 13 to 20 per cent in the output of semi-finished steel compared to the same period in 1979. Actual output in the fourth quarter declined 18.9 per cent from the corresponding quarter of a year earlier. The following products were exempted from quotas: tin plate, rails, large diameter pipe, steel castings and specialty steel, other than stainless containing more than 5 per cent alloy. Small steel companies producing less than 6 000 t per quarter were also exempted from the quota system. No minimum prices and no import quotas were set, although the EEC expected that understandings could be reached with foreign suppliers to hold imports at an acceptable level. Although prices improved marginally by year-end, the situation remained serious.

British Steel Corporation announced a decision in 1980 to reduce steelmaking capacity by 25 per cent to 15 million t at its operations in the United Kingdom. Ongoing financial losses, labour problems and weak markets continued to plague efforts to reverse the company's plight.

China has postponed Phase II of a $4.8 billion, 6 million tpy steel complex at Paoshan, situated near Shanghai. Nippon Steel Corporation, along with other Japanese and West German companies, were contracted to build the complex. Phase I of the project, involving a 3 million tpy blast furnace, was under construction and scheduled for completion by the end of 1982. Phase II was to have included a second blast furnace and a hot strip mill.

OUTLOOK

Western world steel markets are expected to remain weak throughout 1981 because of a depressed level of economic activity and sluggish consumption, held in check by high inflation, unemployment and interest rates in most countries. Sectors which have been seriously affected by these factors include the construction industry, motor vehicles, and consumer durables. The situation in western Europe at year-end 1980 remained serious and there appeared to be no indication of a significant recovery throughout much of 1981. Japan also has

TABLE 9. WORLD RAW STEEL PRODUCTION, 1979 AND 1980

	1979	1980P
	(million tonnes)	
U.S.S.R.	149.1	152.0
Japan	111.7	111.5
United States	123.3	100.8
West Germany	46.0	44.1
People's Republic of China	34.4	33.0
Italy	24.3	26.7
France	23.4	23.3
Poland	19.2	20.0
Canada	16.1	15.9
Brazil	13.9	15.4
Czechoslovakia	14.8	14.8
Romania	12.9	13.5
Spain	12.3	12.7
Belgium	13.4	12.3
United Kingdom	21.5	11.5
India	10.1	9.4
South Africa	8.9	8.9
Republic of Korea	7.6	8.6
Australia	8.1	7.6
East Germany	7.0	7.4
Mexico	7.0	7.1
Democratic Republic of Korea	5.3	5.6
Netherlands	5.8	5.3
Austria	4.9	4.6
Luxembourg	4.9	4.6
Taiwan	4.3	4.2
Sweden	4.7	4.2
Hungary	3.9	4.0
Yugoslavia	3.5	3.5
Argentina	3.2	2.7
Bulgaria	2.5	2.5
Finland	2.5	2.5
Turkey	2.4	2.4
Others	14.3	15.1
Total	747.2	717.7

Source: International Iron and Steel Institute.

P Preliminary.

experienced a moderation in economic activity, and domestic markets for steel in that country are expected to be slower than in 1980. A notable exception in this otherwise lack-lustre outlook on global economic activity is the United States, where there was some evidence of recovery in the last three months of 1980. Steel orders were approaching productive capacity during these three months. The U.S. economy is forecast to show modest strength through the first half of 1981.

The Canadian economy is experiencing many of the problems faced by other countries. In this regard, the automotive, residential construction, agricultural equipment and appliance sectors can anticipate another difficult year. However, other consuming markets such as oil country goods, railway operating, and energy- and industry-investment sectors are expected to remain at a high level of activity throughout 1981. Furthermore, continuing strength during 1981 in the United States economy will have a positive impact on Canadian steel consumption. Canadian steel exports are likely to remain competitive on world markets, particularly while the exchange rate on the Canadian dollar provides a strong incentive to export. Based on these considerations, Canadian production and deliveries of iron and steel products could be somewhat higher in 1981 than the record levels achieved in 1979 and 1980. An offsetting factor is the possibility of a work stoppage at Canada's two largest steel mills. Union contracts at both Stelco and Algoma expire on July 31, 1981.

Prices are expected to remain firm throughout 1981, with modest increases during the year to account for higher costs of production.

In the longer-term, Canadian iron and steel plants are well placed to take advantage of a renewed strength in world markets. Most Canadian companies have just completed, have under construction, or are well advanced in the planning stages of major renovation and expansion programs. Several of these projects have been undertaken in anticipation of new demand growth in the energy sector. The prebuild section of the Alaska Highway natural gas pipeline will provide a firm market for pipe in the near-term, but if the continuing debate over resources between the federal government and the oil and gas producing provinces is not resolved soon, there could be a slowdown in the development of these resources and a corresponding slump in pipe and tube requirements.

TABLE 10. CANADIAN CRUDE STEEL SUPPLY AND DEMAND, 1970 AND 1975-80

	Crude steel production	Imports[1]		Exports[1]		Indicated consumption[2]	
		A[3]	B[4]	A[3]	B[4]	A	B
	(000 tonnes)						
1970	11 200	1 524	1 986	1 696	2 086	11 028	11 100
1975	13 025	1 713	2 194	1 168	1 723	13 570	13 496
1976	13 290	1 374	1 825	1 865	2 393	12 799	12 722
1977	13 631	1 520	2 032	2 232	2 767	12 919	12 896
1978	14 898	1 632	2 278	2 884	3 581	13 646	13 595
1979	16 078	2 324	2 966	2 767	3 553	15 635	15 491
1980P	15 901	1 433	2 071	3 838	4 594	13 496	13 378

Source: Statistics Canada.

[1] Trade of Canada, adjusted to equivalent crude steel by Energy, Mines and Resources, Canada. [2] Production plus imports, less exports, with no account taken for stocks. The two columns of figures depend on the two sets of values for trade. [3] Calculations: total finished steel (all hot and cold-rolled steel but excluding wire, steel forgings, pipe and tube) divided by 0.77 plus steel castings, ingots and semis (See Table 6). [4] Calculations: total hot and cold-rolled steel, steel forgings, wire, and steel pipe and tube, divided by 0.75, plus steel castings (piston ring castings), ingots (ingot moulds and stools), and semis.

P Preliminary.

TABLE 11. CANADA, EXPORTS OF STEEL SCRAP BY PROVINCE, 1978-80

		1978		1979		1980P	
		World	U.S.	World	U.S.	World	U.S.
Newfoundland	tonne	168	168	-	-	-	-
	$000	16	16	-	-	-	-
Nova Scotia	tonne	940	486	133	64	209	59
	$000	196	107	64	17	44	12
New Brunswick	tonne	118	118	46	3	405	357
	$000	13	13	10	...	34	21
Quebec	tonne	225 949	18 195	299 499	14 543	264 903	7 904
	$000	16,479	1,480	38,830	1,713	33,979	997
Ontario	tonne	381 756	349 908	402 257	378 022	241 332	231 740
	$000	28,334	23,874	35,594	32,587	26,398	24,983
Manitoba	tonne	2 761	2 761	9 940	9 866	6 924	6 887
	$000	346	346	1,412	1,399	1,243	1,237
Saskatchewan	tonne	18	18	699	699	2 080	2 080
	$000	8	8	154	153	290	290
Alberta	tonne	1 524	1 504	5 317	5 153	793	793
	$000	121	118	581	537	99	99
British Columbia	tonne	94 930	92 282	139 354	134 532	116 583	110 443
	$000	6,889	6,487	12,210	11,570	13,936	12,951
Canada total	tonne	708 164	465 440	857 245	542 882	633 229	360 263
	$000	52,402	32,449	88,855	47,976	76,023	40,590

Source: Statistics Canada.

P Preliminary; - Nil; ... Less than $500.

TABLE 12. CANADA, IMPORTS OF STEEL SCRAP BY PROVINCE, 1978-1980

		1978		1979		1980P	
		World	U.S.	World	U.S.	World	U.S.
Nova Scotia	tonne	152	152	-	-	175	175
	$000	9	9	-	-	17	17
New Brunswick	tonne	434	434	1 442	1 442	640	640
	$000	43	43	116	116	92	92
Quebec	tonne	64 267	64 263	52 313	52 309	56 641	56 628
	$000	3,336	3,296	5,187	5,187	4,361	4,359
Ontario	tonne	277 606	277 399	343 721	343 099	362 487	362 478
	$000	17,857	17,792	31,862	31,814	31,019	31,015
Manitoba	tonne	85 981	85 981	90 222	90 222	56 385	56 385
	$000	4,730	4,730	8,271	8,271	3,823	3,823
Saskatchewan	tonne	155 407	155 407	177 626	177 626	146 801	146 801
	$000	9,690	9,690	16,950	16,950	14,579	14,579
Alberta	tonne	81 864	81 864	69 510	69 510	41 682	41 682
	$000	3,722	3,722	6,096	6,096	4,317	4,317
British Columbia	tonne	2 272	2 249	2 677	1 908	2 999	2 669
	$000	158	156	256	204	300	276
Canada total	tonne	667 983	667 749	737 511	736 116	667 810	667 458
	$000	39,545	39,438	68,738	68,638	58,508	58,478

Source: Statistics Canada.
P Preliminary; - Nil.

TABLE 13. CANADA, EXPORTS OF STAINLESS STEEL SCRAP, BY PROVINCE OF LADING, 1978-80

		1978		1979		1980P	
		World	U.S.	World	U.S.	World	U.S.
Nova Scotia	tonne	678	480	243	14	157	52
	$000	281	131	178	10	155	41
Prince Edward Island	tonne	17	17	-	-	-	-
	$000	13	13	-	-	-	-
New Brunswick	tonne	233	115	618	-	154	-
	$000	136	62	260	-	120	-
Quebec	tonne	6 497	4 300	6 693	3 211	4 638	1 518
	$000	2 415	1 452	5 400	2 296	3 319	1 350
Ontario	tonne	10 463	9 087	15 539	10 264	11 781	7 348
	$000	4 779	4 120	7 638	4 946	9 900	5 835
Manitoba	tonne	202	202	30	30	154	154
	$000	70	70	23	23	71	71
Saskatchewan	tonne	-	-	-	-	69	69
	$000	-	-	-	-	10	10
Alberta	tonne	74	74	215	215	70	70
	$000	76	76	145	145	60	60
British Columbia	tonne	2 743	2 375	4 082	3 601	1 603	627
	$000	1 118	860	1 332	998	1 082	341
Canada Total	tonne	20 907	16 650	27 420	17 335	18 626	9 838
	$000	8 888	6 784	14 976	8 418	14 717	7 708

Source: Statistics Canada.
P Preliminary; - Nil.

TABLE 14. CANADA, ROLLED STEEL SUPPLY AND DEMAND, 1977-80

	Producer or Mill Shipments[1]	Exports[2]	Imports[3]	Apparent Rolled Steel Consumption[4]	Raw Steel Production[5]
			(000 tonnes)		
1977	10 327	1 761	1 168	9 734	13 631
1978	11 693	2 267	1 257[r]	10 683[r]	14 898
1979	12 230	2 132	1 819	11 917	16 078
1980P	12 295	3 020	1 115	10 390	15 901
% Change 1980/1979	+0.5	+41.6	- 38.7	-12.8	-1.1

Source: Statistics Canada.

[1] Comprises domestic shipments plus producer exports. A portion of domestic shipments to warehouses and steel service centres is also exported. Excludes steel castings amounting to 134 000 t in 1977, 157 000 t in 1978, 200 000 t in 1979, and 198 000 t in 1980. [2] Total exports includes producer exports plus exports from warehouses and steel service centres. Excludes exports of pipe, wire, forgings and steel castings. [3] Excludes imports of pipe, wire forgings and steel castings. [4] Excludes apparent consumption of steel castings. [5] Includes production of steel castings amounting to 149 099 t in 1977, 170 493 t in 1978, 223 353 t in 1979 and 217 266 t in 1980.
P Preliminary; [r] Revised.

TABLE 15. PRICES FOR RAW MATERIALS AND SELECTED STEEL PRODUCTS, 1979 AND 1980[1]

	Currency	1979	1980
Raw Materials			
Iron Ore Pellets, Lake Erie Base Price, per metric iron unit[2]	$US	0.667	0.725
Coal, imported medium volatile bituminous, long term contract, cif Ontario steel mills,	$Cdn	68.00	73.00
Scrap, Number 1 heavy melting, per tonne	$US	95.00	100.00
Direct Reduced Iron, per tonne	$US	115.00	130.00
Basic Pig Iron, per tonne	$Cdn	229.00	240.00
Steel		($Cdn per tonne)	
Hot Rolled Sheet		356.00	391.00
Cold Rolled Sheet		424.00	464.00
Galvanized Sheet		479.00	521.00
Tin Plate		636.00	700.00
Plate		397.00	442.00
Large Structurals		397.00	436.00

Sources: **Skillings Mining Review; Iron Age;** and Energy, Mines and Resources Canada.

[1] Prices in effect at end of December of each year. [2] One iron unit equals one per cent of a tonne. Hence, iron ore pellets with a grade of 65 per cent iron would contain 65 iron units per t.

Lead

M.J. GAUVIN

The lead market was weak during 1980, with prices falling sharply from the highs established during 1979. World mine production was slightly lower than in 1979 while metal production and consumption fell 184 000 tonnes (t) (4.3 per cent) and 222 000 t (5.4 per cent), respectively.

CANADIAN DEVELOPMENTS

Canadian mine production of lead in 1980 was 296 535 t contained in concentrates, a decrease of 13.2 per cent from the 341 777 t produced in 1979. Primary refined production was 162 463 t compared with 183 769 the previous year. Exports of lead in ores and concentrates dropped slightly to 147 226 t while exports of refined metal increased 7.3 per cent to 126 541 t.

Development of a number of mine projects continued during the year. The $53 million expansion at the Number 12 mine of Brunswick Mining and Smelting Corporation Limited is to be completed early in 1981. This will increase mine capacity to 10 000 tpd of ore and its capacity to produce lead and zinc in concentrates by 10 000 t and 30 000 t, respectively. Noranda Mines Limited is proceeding with the development of its "F" Zone mine in the Sturgeon Lake area of Ontario. It is scheduled to start production in 1981 producing 1 000 t of lead in concentrates and 11 000 t of zinc in concentrates. The ore will be processed by Mattabi Mines Limited.

Cominco Ltd. is expanding the capacity of its primary lead smelter and refinery at Trail, British Columbia to 180 000 tpy by 1985 from its present capacity of 145 000 t. Cominco, the operator for Arvik Mines Ltd., is developing the Polaris zinc-lead mine on Little Cornwallis Island in the Canadian high arctic. Polaris, the most northerly mine in the world, is expected to cost $150 million and its 2 000 tpd mill should produce 30 000 tpy of lead in concentrates and 100 000 tpy of zinc in concentrates when production starts in 1982.

Cyprus Anvil Mining Corporation is proceeding with the development of its Vangorda and Grum deposits at a cost of $240 million. Cyprus plans to bring the Vangorda into production in 1985 and the Grum in 1988, and blend these ores with ore from the existing Faro mine.

Consumption of primary and secondary lead in 1979 is estimated at 68 571 t and 29 447 t respectively, for a total consumption of 98 018 t. Total consumption in 1978 was 100 762 t.

WORLD INDUSTRY

Non-socialist world mine production of lead in 1980 is estimated at 2 536 000 t compared with 2 544 000 t in 1979. During the year 103 000 t of new mine capacity started into production. Almost all of this new capacity is accounted for by the Broken Hill mine of

TABLE 1. CANADA, LEAD PRODUCTION, TRADE AND CONSUMPTION, 1979 AND 1980

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Production				
All forms[1]				
Yukon	78 250	103,374,279	74 584	81,475,000
British Columbia	84 452	111,567,385	71 501	78,107,000
Northwest Territories	60 646	80,117,935	53 070	57,974,000
New Brunswick	72 850	96,239,775	18 673	53,170,000
Nova Scotia	-	-	10 925	11,934,000
Ontario	6 969	9,206,177	10 268	11,217,000
Newfoundland	7 013	9,265,343	4 309	4,707,000
Manitoba	375	495,822	396	433,000
Quebec	190	251,316	107	117,000
Total	310 745	410,518,032	273 833	299,134,000
Mine output[2]	341 777	..	296 535	..
Refined production[3]	183 769	..	162 463	..
Exports				
Lead contained in ores and concentrates				
Japan	72 613	69,730,000	89 849	68,605,000
West Germany	18 955	13,559,000	18 282	12,392,000
United States	35 981	8,787,000	13 381	8,124,000
U.S.S.R.	10 834	10,648,000	8 662	7,173,000
Belgium-Luxembourg	3 323	1,816,000	9 592	5,740,000
Other countries	9 779	5,231,000	7 460	4,821,000
Total	151 485	109,771,000	147 226	106,855,000
Lead pigs, blocks and shot				
United Kingdom	38 233	47,621,000	36 121	36,922,000
United States	61 183	74,963,000	32 973	31,555,000
West Germany	902	1,061,000	15 394	14,496,000
Netherlands	4 147	5,217,000	4 886	12,248,000
U.S.S.R.	-	-	11 664	10,181,000
Italy	6 682	6,407,000	8 348	8,948,000
Other countries	6 845	7,465,000	17 155	18,486,000
Total	117 992	142,734,000	126 541	132,836,000
Lead and alloy scrap (gross weight)				
West Germany	5 878	3,083,000	10 640	5,776,000
United States	5 621	3,946,000	2 662	1,961,000
Sweden	4 235	3,146,000	1 536	1,161,000
South Korea	1 639	638,000	1 460	738,000
Taiwan	1 166	470,000	1 191	530,000
United Kingdom	772	749,000	376	448,000
Denmark	265	301,000	574	381,000
Other countries	2 287	1,078,000	2 664	897,000
Total	21 863	13,411,000	21 103	11,892,000

TABLE 1. (cont'd)

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Lead fabricated materials not elsewhere specified				
United States	8 678	10,848,000	3 780	4,055,000
United Kingdom	729	917,000	216	226,000
Denmark	14	51,000	214	224,000
Belgium-Luxembourg	-	-	182	196,000
Other countries	230	227,000	285	288,000
Total	9 651	12,043,000	4 677	4,989,000
Imports				
Lead pigs, blocks and shot	2 133	2,655,000	2 602	3,051,000
Lead oxide, dioxide and tetroxide	331	525,000	926	1,264,000
Lead fabricated materials not elsewhere specified	501	892,000	1 165	1,465,000
Lead in concentrates	9 064	8,774,000	..	..
Lead in dross, skimmings and sludge	1 756	483,000	..	..
Lead and lead alloy scrap	58 656	23,325,000	..	..

	1979			1980P		
	Primary	Secondary[4]	Total (tonnes)	Primary	Secondary	Total
Consumption						
Lead used for, or in the production of:						
Antimonial lead	1 209	x	x			
Battery and battery oxides	44 509	4 729	49 238	..	..	..
Cable covering	x	x	x			
Chemical uses; white lead, red lead, litharge, tetraethyl lead, etc.	14 612	6 556	21 168			
Copper alloys; brass, bronze, etc.	302	70	372			
Lead alloys:						
solders	1 765	5 780	7 545			
others (including babbitt, type metals, etc.)	306	2 548	2 854			
Semi-finished products: pipe, sheet, traps, bends, blocks for caulking, ammunition etc.	2 172	x	x			
Other lead products	3 696	9 764	16 841			
Total, all categories	68 571	29 447	98 018	..	..	..

Source: Statistics Canada; Energy, Mines and Resources Canada.

[1] Lead content of base bullion produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable lead in domestic ores and concentrates exported. [2] Lead content of domestic ores and concentrates produced. [3] Primary refined lead from all sources. [4] Includes all remelt scrap lead and scrap lead used to make antimonial lead.
P Preliminary; - Nil; .. Not available; x Confidential, but included in "other".

TABLE 2. CANADA, LEAD PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975-80

	Production		Exports				
	All forms[1]	Refined[2]	In ores and concentrates	Refined	Total	Imports Refined[3]	Consumption[4]
	(tonnes)						
1970	353 063	185 637	186 219	138 637	324 856	1 995	84 765
1975	349 133	171 516	211 909	110 882	322 791	1 962	89 193
1976	256 324	175 720	140 933	114 421	255 354	1 941	107 654
1977	280 955	187 457	137 820	130 819	268 639	821	106 962
1978	319 809	194 054	142 693	131 951	274 644	1 715	100 762
1979	310 745	183 769	151 485	117 992	269 477	2 133	98 018
1980P	273 833	162 463	147 226	126 541	273 767	2 602	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Lead content of base bullion produced from domestic primary materials (concentrates, slags, residues, etc.) plus the estimated recoverable lead in domestic ores and concentrates exported. [2] Primary refined lead from all sources. [3] Lead in pigs and blocks. [4] Consumption of lead, primary and secondary in origin.
PPreliminary; .. Not available.

TABLE 3. UNITED STATES CONSUMPTION OF LEAD BY END-USE, 1979 AND 1980

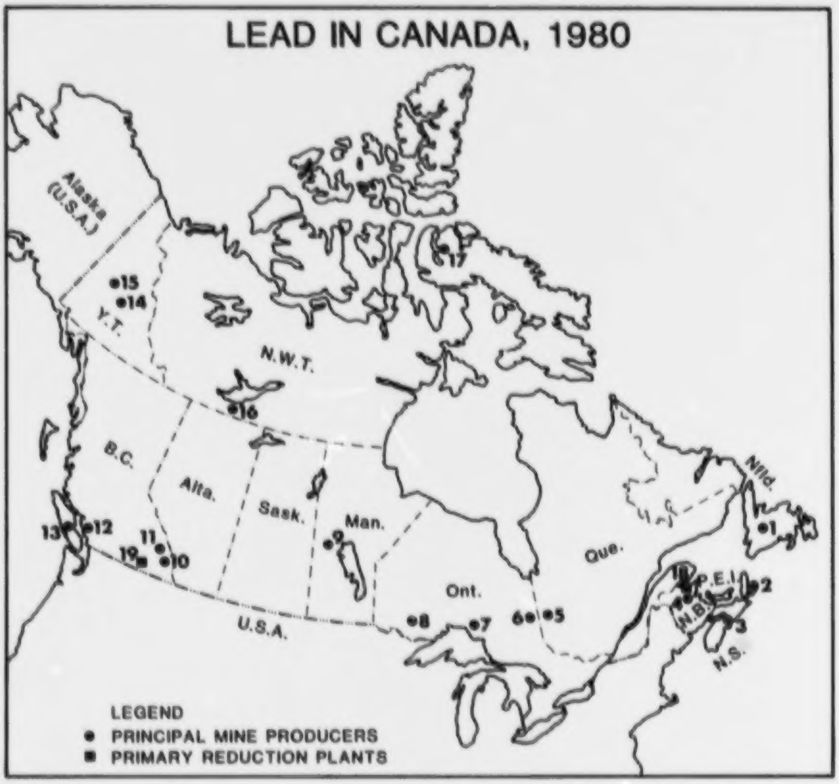
	1979	1980P
	(tonnes)	
Storage batteries	814 332	504 795
Gasoline antiknock additives	186 945	127 901
Solder, type metal, terne metal and bearing metals	78 484	44 502
Pigments	90 790	68 402
Ammunition - shot and bullets	53 236	48 868
Sheet and pipe	27 618	11 456
Cable covering	16 393	13 064
Caulking	8 017	2 382
Other uses	82 520	32 459
Total reported[1]	1 358 335	853 829
Estimated undistributed consumption	-	194 371
Grand Total	1 358 335	1 048 200

Source: United States Bureau of Mines, **Mineral Industry Surveys**, "Lead Industry in December 1980".
[1] Includes lead content of scrap used directly in fabricated products.
PPreliminary; - Nil.

TABLE 4. NON-COMMUNIST WORLD MINE PRODUCTION OF LEAD, 1979 AND 1980

	1979	1980P
	(000 tonnes)	
United States	537	562
Australia	402	382
Canada	342	296
Peru	184	189
Mexico	174	146
Republic of South Africa	42	132
Yugoslavia	130	122
Morocco	111	116
Spain	74	87
Sweden	84	70
Ireland	69	58
Japan	47	45
Argentina	32	32
West Germany	33	31
Denmark	32	30
France	30	29
Brazil	28	25
Other countries	193	184
Total	2 544	2 536

Sources: Energy, Mines and Resources Canada; International Lead and Zinc Study Group, Monthly Bulletin, November 1981.
PPreliminary.


LEAD IN CANADA, 1980
Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
15
14
17
16
13
12
11
19
10
9
8
7
6
5
1
2
3
LEGEND
● PRINCIPAL MINE PRODUCERS
■ PRIMARY REDUCTION PLANTS

Principal mine producers
(numbers refer to locations on map above)

1. ASARCO Incorporated (Buchans Unit)
2. Barymin Explorations Limited (Yava Unit)
3. Esso Minerals Canada (Gays River)
4. Brunswick Mining and Smelting Corporation Limited (Nos. 12 and 6 mines)
   Heath Steele Mines Limited
5. Louvem Mining Company Inc. (Louvem Unit)
6. Texasgulf Canada Ltd.
7. Noranda Mines Limited (Geco Division)
8. Corporation Falconbridge Copper (Sturgeon Lake Joint Venture)
   Mattabi Mines Limited
   Noranda Mines (Lyon Lake)
9. Hudson Bay Mining and Smelting Co., Limited (Flin Flon, Chisel Lake, Ghost Lake mines)
10. Cominco Ltd. (Sullivan mine)
11. Dickenson Mines Limited (Silmonac mine)
12. Northair Mines Ltd.
13. Western Mines Limited
14. Cyprus Anvil Mining Corporation
15. United Keno Hill Mines Limited
16. Pine Point Mines Limited
17. Nanisivik Mines Ltd.

Primary Reduction Plants

18. Brunswick Mining and Smelting Corporation Limited, Smelting Division
19. Cominco Ltd.

TABLE 5. PRINCIPAL LEAD MINES IN CANADA, 1980 (1979)

Company and Location	Mill Capacity	Copper	Lead	Zinc	Silver	Gold	Ore Milled	Lead Concentrates			Lead Content All[1] Concentrates	Destination[2] of Concentrates
	(tonnes/ day)	(%)	(%)	(%)	(grams/ tonne)	(grams/ tonne)	(tonnes)	Produced (tonnes)	Grade (%)	Content (tonnes)	(tonnes)	
Newfoundland												
ASARCO Incorporated, Buchans Unit, Buchans	1 100 (1 100)	0.85 (1.04)	5.42 (6.51)	9.38 (11.64)	102.5 (109.7)	0.82 (0.82)	75 297 (113 398)	6 319 (11 292)	52.60 (54.41)	3 324 (6 144)	3 822 (7 003)	1,3 (3)
Nova Scotia												
Barymin Explorations Limited, Yava Unit	550 (550)	- (-)	4.56 (4.20)	- (-)	5.11 (4.80)	- (-)	172 815 (54 431)	10 181 (2 903)	68.24 (71.00)	6 948 (2 061)	6 948 (2 061)	5 (5)
Esso Resources Canada Limited Gays River	1 500 (1 500)	- (-)	1.43 (2.50)	2.04 (4.50)	- (-)	- (-)	261 942 (45 359)	4 802 (1 315)	75.10 (72.00)	3 606 (947)	3 635 (1 062)	5 (5)
New Brunswick												
Brunswick Mining and Smelting Corporation Limited, Bathurst	9 050 (9 050)	0.31 (0.31)	3.56 (3.61)	8.80 (8.93)	97.4 (95.0)	- (-)	1 848 036 (2 971 516)	169 292 (247 175)	26.81 (29.22)	45 395 (72 236)	50 716 (72 236)	1,2,5,8 (1,2,5,6,7,8)
Heath Steele Mines Limited, Newcastle	3 600 (3 600)	0.84 (0.91)	1.45 (1.53)	4.34 (4.55)	55.2 (55.2)	1.03 (0.69)	1 252 406 (1 172 737)	39 761 (42 904)	20.10 (21.47)	7 992 (9 211)	11 351 (11 852)	1,3,5,7,8 (1,3,5,7,8)
Quebec												
Louvem Mining Company Inc. (SOQUEM), Val d'Or	900 (900)	0.15 (0.04)	0.11 (0.55)	3.89 (4.51)	30.4 (137.8)	1.82 (0.93)	224 530 (72 261)	- (701)	- (33.90)	- (238)	181 (312)	- (3)
Ontario												
Corporation Falconbridge Copper, Sturgeon Lake Joint Venture, Sturgeon Lake	1 100 (1 100)	1.46 (2.17)	1.05 (1.23)	5.89 (8.70)	131.7 (169.7)	0.48 (0.62)	371 623 (373 953)	6 826 (3 846)	29.53 (36.53)	2 016 (1 405)	2 745 (2 908)	2 (1,2)

Mattabi Mines Limited, Sturgeon Lake	2 700 (2 700)	0.44 (0.55)	0.87 (0.77)	7.24 (6.91)	106.6 (97.7)	- (0.38)	846 940 (945 015)	20 398 (15 046)	21.64 (27.83)	4 414 (4 187)	5 618 (5 453)	1,2,3 (2)
Noranda Mines Limited, Geco Division Manitouwadge	4 550 (4 550)	1.47 (1.82)	0.14 (0.11)	3.32 (3.24)	60.7 (59.0)	0.10 (0.10)	1 358 317 (1 475 841)	1 536 (918)	46.13 (56.00)	708 (514)	1 659 (1 485)	1,2 (2)
Texasgulf Canada Ltd., Kidd Creek Mine, Timmins	12 250 (9 050)	1.83 (1.95)	0.18 (0.15)	5.78 (5.47)	86.4 (76.0)	- (-)	3 899 575 (3 680 858)	27 785 (12 460)	11.53 (12.29)	3 204 (1 531)	5 293 (3 649)	3 (3)
Manitoba-Saskatchewan												
Hudson Bay Mining and Smelting Co., Limited, Flin Flon concentrator	7 250 (7 250)	1.67 (1.64)	0.15 (0.17)	2.11 (2.36)	19.8 (22.8)	1.30 (1.27)	945 379 (870 792)	- (463)	- (56.60)	- (262)	521 (974)	- (2)
Snow Lake concentrator[4]	3 450 (3 450)	2.65 (2.72)	0.23 (0.14)	3.23 (4.03)	16.7 (12.3)	1.10 (1.10)	756 283 (121 412)	953 (295)	60.43 (59.32)	576 (175)	1 127 (354)	2 (2)
British Columbia												
Cominco Ltd., Sullivan mine, Kimberley	9 050 (9 050)	- (-)	3.85 (5.33)	2.73 (3.73)	44.6 (63.8)	- (-)	2 132 416 (2 047 726)	109 917 (155 477)	62.21 (60.98)	68 380 (94 810)	72 675 (100 156)	2 (2)
Dickenson Mines Limited Silmonac mine, Sandon	(100) (100)	- (-)	3.21 (4.89)	3.03 (4.51)	295.9 (478.6)	- (-)	28 223 (19 625)	1 420 (1 500)	58.50 (60.64)	831 (910)	845 (923)	2 (2)
Northair Mines Ltd., Alta Lake	250 (250)	0.50 (0.50)	1.38 (0.91)	2.15 (1.50)	32.3 (26.3)	8.37 (11.35)	71 478 (91 587)	1 879 (1 759)	46.55 (39.65)	874 (697)	936 (738)	2 (2)
Teck Corporation, Beaverdell	100 (100)	- (-)	0.23 (0.28)	0.56 (0.63)	290.7 (320.2)	- (-)	38 550 (33 662)	283 (317)	20.95 (22.74)	59 (72)	80 (92)	2 (2)
Western Mines Limited, Lynx and Myra Falls mines, Buttle Lake	900 (900)	1.22 (1.32)	1.23 (1.37)	7.58 (8.45)	124.1 (131.3)	2.74 (2.91)	278 244 (266 877)	6 592 (6 635)	42.00 (43.04)	2 768 (2 856)	3 275 (3 398)	2 (2)

TABLE 5. (cont'd.)

Company and Location	Mill Capacity (tonnes/	Copper (%)	Lead (%)	Zinc (%)	Silver (grams/	Gold (grams/	Ore Milled (tonnes)	Lead Concentrates Produced (tonnes)	Lead Concentrates Grade (%)	Lead Concentrates Content (tonnes)	Lead Content All[1] Concentrates (tonnes)	Destination[2] of Concentrates
Yukon Territory												
Cyprus Anvil Mining Corporation, Faro	9 050 (9 050)	- (-)	3.12 (3.26)	4.68 (5.28)	47.0 (25.0)	0.25 (0.10)	2 825 150 (2 823 031)	130 038 (146 120)	52.48 (52.72)	68 248 (77 034)	73 711 (81 032)	4,5,8 (4,5,8)
United Keno Hill Mines Limited, Elsa	450 (450)	- (-)	3.39 (3.00)	(0.79) (-)	787.2 (818.4)	- (-)	79 636 (112 783)	4 705 (5 715)	34.00 (45.00)	1 600 (2 572)	1 603 (2 572)	3 (3)
Northwest Territories												
Nanisivik Mines Ltd., Baffin Island	2 200 (2 200)	- (-)	2.37 (1.39)	14.28 (12.92)	86.3 (66.2)	- (-)	435 147 (615 459)	13 375 (12 591)	70.60 (60.73)	9 442 (7 646)	9 967 (8 206)	6 (5,8)
Pine Point Mines Limited, Pine Point	10 000 (10 000)	- (-)	1.96 (1.91)	5.49 (5.48)	- (-)	- (-)	3 289 329 (2 985 536)	74 170 (67 014)	76.04 (73.67)	56 399 (49 369)	61 421 (53 965)	2,3,4,7,8 (2,3,4,8)

Source: Data provided by companies in response to questionnaire from Energy, Mines and Resources Canada.

[1] Includes lead in zinc, copper, silver and bulk concentrates. [2] Destination: (1) Brunswick; (2) Trail; (3) United States; (4) Japan, (5) West Germany; (6) Belgium, (7) United Kingdom, (8) Unspecified and other countries.
- Nil.

TABLE 6. NON-COMMUNIST WORLD PRODUCTION[1] OF REFINED LEAD, 1979 AND 1980

	1979	1980P
	(000 tonnes)	
United States	1 226	1 150
West Germany	373	350
United Kingdom	368	325
Japan	283	305
Australia	255	232
Canada	252	235
France	220	219
Mexico	225	185
Italy	126	134
Spain	129	124
Belgium	92	106
Yugoslavia	111	102
Peru	90	87
Brazil	98	85
Republic of South Africa	72	78
Other countries	370	389
Total	4 290	4 106

Sources: Energy, Mines and Resources Canada, International Lead and Zinc Study Group, Monthly Bulletin, November 1981.

[1] Total production by smelters or refineries, or refined pig lead, plus the lead content of antimonial lead - including production on toll in the reporting country - regardless of the type of source material; i.e., whether ores, concentrates, lead bullion, lead alloys, mattes, residues, slag or scrap. Remelted pig lead and remelted antimonial lead are excluded.
PPreliminary.

Black Mountain Mineral Development Company Limited at Aggeneys, South Africa. The Broken Hill mine is expected to produce 90 000 tpy of lead and 18 000 tpy of zinc in concentrates. World lead metal production in 1980 is estimated at 4 106 000 t compared with 4 290 000 in 1979. During 1980, secondary lead smelter capacity rose by 54 000 t with the start-up of a new secondary plant at Savanna, Illinois. Expansion of a primary smelter in Morocco increased primary capacity by 20 000 t.

TABLE 7. NON-COMMUNIST WORLD CONSUMPTION[1] OF REFINED LEAD, 1979 AND 1980

	1979	1980P
	(000 tonnes)	
United States	1 344	1 094
Japan	365	392
West Germany	361	333
United Kingdom	333	296
Italy	258	275
France	211	212
Spain	115	114
Canada	120	110
Yugoslavia	84	105
Mexico	110	96
Brazil	99	83
Australia	71	71
Other countries	681	748
Total	4 152	3 929

Source: International Lead and Zinc Study Group, Monthly Bulletin, November 1981.
[1] Consumption of those types of metal as reported under "production" in Table 6.
PPreliminary.

PRICES

After hitting an all-time high in September 1979 of 71 cents a pound in Canadian funds and 67 cents in United States funds, the producers' published price dropped to 62.5 and 55.0 cents a pound respectively at the end of 1979. During 1980, following a series of price drops in January, April, May and June, the producer price at the end of June was 39 cents a pound in Canada and 34 cents in the United States. Subsequent increases, the last on September 30, brought the prices in Canada and the United States up to 51 cents and 45 cents respectively. However, an anticipated increase in demand for lead, particularly in automotive batteries, did not materialize and in late November and early December producers lowered prices to 45.5 cents a pound in Canada and 39 cents in the United States. The monthly average spot price on the London Metal Exchange (LME) was £494 per t in January, rose to £510.5 in February, then dropped gradually to £316.2 in June. It subsequently rose to £367.7 in September before declining to £316.9 in December.

TABLE 8. LEAD METAL PRICES, 1980

Month	London Metal Exchange Spot	U.S. Domestic Delivered Price	Canada Delivered Carlots
	£ per tonne	¢US/ pound	¢Cdn/ pound
January	494.0	49.9	57.50
February	510.5	50.0	57.00
March	508.7	49.2	57.00
April	438.5	44.0	51.88
May	340.5	36.0	43.00
June	316.2	34.2	40.20
July	341.7	35.6	41.13
August	359.9	41.0	46.75
September	367.7	42.3	48.60
October	360.8	45.0	51.00
November	340.0	43.8	51.00
December	316.9	39.0	47.10
1980 Average	391.3	42.5	49.35
1979 Average	567.7	52.6	59.79

Source: International Lead and Zinc Study Group, Monthly Bulletin, May 1981; **Northern Miner** quotes as compiled by Energy, Mines and Resources Canada.

OUTLOOK

The outlook is for a continued balance in lead demand and supply. Increasing mine capacity is expected to be able to supply any short-term growth in demand. Should any sharp increase in demand develop, the resulting increase in price will raise the availability of scrap and the secondary industry would be able to expand production to satisfy demand.

TARIFFS, 1980

CANADA

Item No.		British Preferential	General Preferential	Most Favoured Nation	General
32900-1	Ores of lead	free	free	free	free
33700-1	Lead, old scrap, pig and block	free	free	free	1¢ per lb.
33800-1	Lead in bars and in sheets	4.9%	3.0%	4.9%	25%
33900-1	Manufacturers of lead not otherwise provided for	16.6%	10.0%	16.6%	30%

MFN Reductions under GATT (effective January 1 of year given)

Item No.	1980	1981	1982	1983	1984	1985	1986	1987
				(%)				
33800-1	4.9	4.8	4.6	4.5	4.4	4.3	4.1	4.0
33900-1	16.6	15.7	14.8	13.9	12.9	12.0	11.1	10.2

UNITED STATES (MFN)

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
602.10	Lead bearing ores per lb. on lead content	0.75¢	- no change -						0.75¢
624.02	Lead bullion	3.5	- no change -						3.5
624.03	Other	3.5	- no change -						3.5
624.04	Lead waste etc.	3.6	3.4	3.2	3.0	2.8	2.7	2.5	2.3

TARIFFS (cont'd)

EUROPEAN ECONOMIC COMMUNITY: (MFN)

Item No.		1980	Base Rate (%)	Concession Rate
26.01	Lead ores & concentrates	free	free	free
78.01	Lead unwrought	3.5	3.5	3.5
	Lead waste & scrap	free	free	free

JAPAN (MFN)

Item No.			(%)	
26.01	Lead ores & concentrates	free	free	free
78.01	Lead unwrought			
	Unalloyed	7.1	7.5	6.0
	Alloyed	8.8	12.0	6.5
	Other	5.4	7.0	4.7
	Lead waste & scrap	3.8	5.0	3.2

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue, Canada; Tariff Schedules of the United States Annotated (1980), U.S. ITC Publication 1011; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 22, No. L342, 1979; Customs Tariff Schedules of Japan, 1979; GATT Documents, 1979.

Lime

D.H. STONEHOUSE

THE CANADIAN INDUSTRY

Lime is a high-bulk, comparatively low-cost commodity and it is uncommon to ship it long distances when the raw material for its manufacture is available in so many localities. The preferred location for a lime plant is obviously near the principal lime markets, adjacent to a source of high-quality raw material and close to a supply of energy. The more heavily populated and industrialized provinces of Ontario and Quebec together produced over 80 per cent of Canada's total lime output in 1980, with Ontario contributing about two-thirds of Canada's total.

Production figures do not include some captive production such as that from pulp and paper plants that burn sludge to recover lime for reuse in the causticization process. With the addition of some new and larger capacity in recent years the industry could produce between 10 000 and 12 000 tpd or about 3.5 million tpy.

Lime is used principally in the steel, pulp and paper, and mining industries where its chemical qualities are required as a flux, in digesting liquors and as a neutralizing agent, respectively. Environmental control in such areas as water and sewage treatment and removal of SO_2 from smelter stack gases and thermal power plant emissions will undoubtedly require large amounts of lime in the near future.

In Canada, markets were good in the eastern provinces, stable in the central provinces and good in the western provinces during 1980. With uranium production off in both Canada and the U.S., markets were expected to be lower. Steel Brothers Canada Ltd. expects to complete the installation of a second kiln at its Pavilion Lake, B.C. plant by mid-1981, adding another 350 tpd to the plant's capacity. Domlim Inc., in late 1980, began running-in its new vertical kiln at St. Adolphe de Dunville, Quebec. The company also operates six vertical kilns at Lime Ridge. Markets should improve, and in the long term the new capacity being brought into production will be fully utilized.

The United States market was not as buoyant as in the previous year. However, Canadian companies such as the Lime Division of the Domtar Chemicals Group, which is expanding its lime plant at Bellefonte, Pennsylvania; Steetley Industries Limited, which purchased National Gypsum Company's lime plant at Gibsonburg, Ohio, and Steel Brothers Canada Ltd., which is constructing a new lime plant at Delta, Utah, consider their expansion into the United States market a logical trend.

TABLE 1. CANADA, LIME PRODUCTION AND TRADE, 1979 AND 1980

	1979		1980P	
	(tonnes)	($000)	(tonnes)	($000)
Production[1]				
By type				
Quicklime	1 662 405	72,523	1 877 000	..
Hydrated Lime	196 920	10,251	186 000	..
Total	1 859 325	82,774	2 063 000	102,810
By province				
Ontario	1 032 156	42,548	1 295 000	60,590
Quebec	438 427	21,402	393 000	21,774
Alberta	161 535	7,031	183 000	9,041
Manitoba	..	3,399	..	4,158
British Columbia	100 408	5,297	64 000	3,832
New Brunswick	..	3,097	..	3,415
Total	1 859 325	82,774	2 063 000	102,810
Imports				
Quick and hydrated				
United States	41 095	3,052	39 006	3,085
West Germany	304	74	1 000	192
United Kingdom	-	-	878	129
France	-	-	18	28
Belgium and Luxembourg	80	40	-	-
Total	41 749	3,166	40 902	3,434
Exports				
Quick and hydrated				
United States	488 687	22,711	399 624	21,021
Barbados	-	-	1 596	258
Honduras	1 270	230	1 153	109
Other countries	906	112	1 145	154
Total	490 863	23,053	403 518	21,542

Source: Energy, Mines and Resources Canada; Statistics Canada.
[1] Producers' shipments and quantities used by producers.
P Preliminary; - Nil; .. Not available.

TABLE 2. CANADA, LIME PRODUCTION, TRADE AND APPARENT CONSUMPTION, 1970 1975-80

	Production[1]					
	Quick	Hydrated	Total	Imports	Exports	Apparent Consumption[2]
	(tonnes)					
1970	1 296 590	224 026	1 520 616	30 649	181 994	1 369 271
1975	1 533 944	199 195	1 733 139	30 099	234 034	1 529 204
1976	1 703 374	227 019	1 930 393	36 882	309 355	1 657 920
1977	1 767 406	232 638	2 000 044	24 480	359 540	1 664 984
1978	1 857 580	176 631	2 034 211	31 130	478 552	1 586 789
1979	1 662 405	196 920	1 859 325	41 479	490 863	1 409 941
1980P	1 877 000	186 000	2 063 000	40 902	403 518	1 700 384

Source: Energy, Mines and Resources, Canada. Statistics Canada.
[1] Producers' shipments and quantities used by producers. [2] Production, plus imports, less exports.
P Preliminary.

TABLE 3. CANADIAN LIME INDUSTRY, 1980

Company	Plant Location	Type of Quicklime
New Brunswick		
Havelock Processing Ltd.	Havelock	High-calcium
Quebec		
Domlim Inc.	Lime Ridge	High-calcium[2]
	St. Adolphe de Dudswell	High-calcium[3]
Domtar Inc.	Joliette	High-calcium[2]
Gulf Canada Limited, Shawinigan Chemical Division	Shawinigan	High-calcium[2]
Quebec Sugar Refinery[1]	St.-Hilaire	High-calcium
Ontario		
The Algoma Steel Corporation, Limited[1]	Sault Ste. Marie	High-calcium and dolomitic
Allied Chemical Canada, Ltd.[1]	Amherstburg	High-calcium
BeachviLime Limited	Beachville	High-calcium
Guelph DoLime Limited	Guelph	Dolomitic[2]
Chromasco Limited[1]	Haley	Dolomitic
Domtar Inc.	Beachville	High-calcium[2]
	Hespeler	Dolomitic[2]
Reiss Lime Company of Canada, Limited	Spragge	High-calcium
Stelco Inc.	Ingersoll	High-calcium[2]
Steetley Industries Limited	Dundas	Dolomitic
Manitoba		
The Manitoba Sugar Company, Limited[1]	Fort Garry	High-calcium
Steel Brothers Canada Ltd.	Faulkner	High-calcium
Alberta		
Canadian Sugar Factories Limited[1]	Taber	High-calcium
	Picture Butte	High-calcium
Steel Brothers Canada Ltd.	Kananaskis	High-calcium
Summit Lime Works Limited	Hazell	High-calcium and dolomitic
British Columbia		
Steel Brothers Canada Ltd.	Kamloops	High-calcium
Texada Lime Ltd.	Fort Langley	High-calcium

Source: Energy, Mines and Resources Canada.

[1] Production for captive use. [2] Hydrated lime produced also. [3] Under construction.

Note: Domtar Inc., Steetley Industries Limited, and Steel Brothers Canada Ltd. operate lime divisions in the United States.

MARKETS AND OUTLOOK

The metallurgical industry provides the largest single market for lime. With increased application of the basic oxygen furnace (BOF) in the steel industry, lime consumption increased greatly in certain areas of the United States and Canada. An increase in the demand for steel will result in the need for more fluxing lime and will encourage the development of captive sources by steel producers. The pulp and paper industry is currently the second-largest consumer of lime, most of which is used in the preparation of digesting liquor and in pulp bleaching. Any reduction of activity in either of these two industry sectors, brought on by strikes or lack of product demand, can have an immediate and serious effect on the lime industry, at least regionally. Developments in mechanical fiberizing in the pulp industry could reduce the current lime requirements of this industry significantly.

The uranium industry uses lime to control hydrogen-ion concentrations during uranium extraction, to recover sodium carbonate and to neutralize waste sludge. In the production of beet sugar, lime is used to precipitate impurities from the sucrate. It is used also in the manufacture of many materials such as calcium carbide, calcium cyanamide, calcium chloride, fertilizers, insecticides, fungicides, pigments, glue, acetylene, precipitated calcium carbonate, calcium hydroxide, calcium sulphate, magnesia and magnesium metal.

The rapidly-growing concern for the safeguarding and treatment of water supplies and the appeal for enforced anti-pollution measures should result in greater use of lime for water and sewage treatment. The removal of sulphur dioxide (SO_2) from hydrocarbon fuels, either during the burning procedure, or from stack gases by either wet or dry scrubbing, could necessitate the use of lime. This may become a major market for this commodity as SO_2 emission regulations are developed. Lime is effective for this purpose, inexpensive, and can be regenerated in systems where the economics would so dictate. The creation of large amounts of gypsum waste sludge during SO_2 removal will present a disposal problem. Paradoxically, the lime industry is itself caught up in the clean-up campaigns sponsored by various levels of government, particularly efforts directed at dust removal.

Soil stabilization, especially for highways, offers a potential market for lime. However, not all soils have the physical and chemical characteristics to react properly with lime to provide a dry, impervious, cemented and stable roadbed. Hydrated lime added to asphalt hot-mix prevents the asphalt from stripping from the aggregate. This could become more important as new technologies relating to asphalt maintenance and repair are adopted and as the sources of good clean aggregate become scarce.

The use of lime-silica bricks, blocks and slabs has not been as popular in Canada as in European countries, although lightweight, cellular, insulating masonry forms have many features attractive to the building construction industry.

TECHNOLOGY

Carbonate rocks are basic to industry. They form about 15 per cent of the earth's crust and fortunately are widely distributed and easily exploitable. The principal carbonate rocks utilized by industry are limestones - sedimentary rocks composed mainly of the mineral calcite ($CaCO_3$) - and dolomites - sedimentary rocks composed mainly of the mineral dolomite ($CaCO_3 \cdot MgCO_3$). Commonly termed limestones, they can be classified according to their content of calcite and dolomite. Their importance to the construction industry is not only as building stone and aggregate but as the primary material in the manufacture of portland cement and lime. Limestones are also used as flux material, in glass manufacture, as refractories, fillers, abrasives, soil conditioners and in the manufacture of a host of chemicals.

Quicklime (CaO or $CaO \cdot MgO$) is formed by the process of calcination, in which limestones are heated to the dissociation temperature of the carbonates (as low as 402°C for $MgCO_3$ and as high as 898°C for $CaCO_3$) and held at that temperature over sufficient time to release carbon dioxide. Although the word "lime" is used generally, and wrongly, to refer to pulverized limestone as well as to forms of burned lime, it should refer only to calcined limestone (quicklime) and its secondary products, slaked lime and hydrated lime. Slaked lime is the product of mixing quicklime and water, hydrated lime is slaked lime dried and, possibly, reground.

Calcining is done in kilns of various types, but essentially those of vertical or rotary design are used. Of comparatively recent design are the rotary hearth, travelling grate, fluo-solid and inclined vibratory types. The high cost of energy has made it imperative to include preheating facilities in any new plant design, and environmental regulations have necessitated the incorporation of dust collection equipment.

TABLE 4. CANADA, CONSUMPTION OF LIME, QUICK AND HYDRATED, 1979 AND 1980 (PRODUCERS' SHIPMENTS AND QUANTITIES USED BY PRODUCERS, BY USE)

	1979		1980P	
	(tonnes)	($000)	(tonnes)	($000)
Chemical and metallurgical				
Iron and steel plants	894 622	37 156	966 007[2]	47 366[2]
Pulp and paper mills	348 404	17 226	303 484	15 724
Water and sewage treatment	42 020	2 103	113 219	5 406
Nonferrous smelters	60 497	2 791	77 533[2]	3 974[2]
Cyanide and flotation mills	53 298	2 433	68 805	3 293
Sugar refineries	24 733	1 657	19 006	947
Other industrial[1]	376 262	16 054	392 090	20 957
Agricultural	13 910	879	17 084[3]	1 135[3]
Road stabilization	17 756	859	8 716[3]	452[3]
Other uses	27 823	1 616	97 056	3 556
Total	1 859 325	82 774	2 063 000	102 810

Sources: Statistics Canada; Energy, Mines and Resources Canada.
[1] Includes glassworks, fertilizer plants, tanneries, uranium plants and other miscellaneous industrial uses. [2] Figures represent quicklime only. Figures for hydrated lime are included in "other industrial" to avoid disclosing confidential company information. [3] Figures represent hydrated lime only. Figures for quicklime are included in "other uses".
P Preliminary.

TABLE 5. WORLD PRODUCTION OF QUICKLIME AND HYDRATED LIME INCLUDING DEAD-BURNED DOLOMITE SOLD AND USED, 1979 AND 1980

	1979P	1980^{e}
	(000 tonnes)	
U.S.S.R.	23 600^{e}	21 300
United States	19 000	16 400
Poland	9 600	8 600
Japan	9 100	8 100
West Germany	9 000	8 100
France	4 600	4 200
Brazil	4 500	4 100
Romania	3 600	..
East Germany	3 600	..
Czechoslovakia	3 000	..
Yugoslavia	2 500	..
Republic of South Africa	2 500	..
Belgium	2 400	1 700
Italy	2 100	2 000
Canada	1 859	2 063
Other countries	11 800	24 200
Total	112 800	100 800

Sources: Energy, Mines and Resources Canada; Statistics Canada; U.S. Bureau of Mines Minerals Yearbook Preprint 1978-79; U.S. Bureau of Mines, Mineral Commodity Summaries, 1981.
P Preliminary; ^{e} Estimated; .. Included in other countries.

Although quicklime and hydrated lime are not of relatively high monetary value, they are transported considerable distances in bulk or in packages if a market exists. Freight costs can represent a large part of the consumer's cost. Production costs have increased significantly as a result of higher energy costs. The industry, on average, uses about 6.4 gigajoules per t of production. New plants have incorporated preheater systems, and the need to replace some of the older less-efficient production capacity with fuel-conserving equipment is well recognized. A new-design, short-rotary kiln (65 metres) and preheater system can reduce energy consumption to about 5.1 gigajoules per t of product.

PRICES

Canada lime prices quoted in Chemical Processing Newsletter

December, 1980

Lime carloads and truckload lots fob plant

High calcium quicklime - bulk	$50.71 per tonne
High calcium hydrated - bulk	$53.62 per tonne

fob - Free on board.

TARIFFS

CANADA

Item No.		British Preferential	General Preferential	Most Favoured Nation	General
29010-1	Lime	free	free	free	25%

UNITED STATES (MFN)

Item No.		
512.11	Lime hydrated	free
512.14	Lime other	free

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated 1980, USITC Publication 1011; U.S. Federal Register, Vol. 44, No. 241.

Magnesium

D. Pearson and G.E. Wittur

CANADA

Chromasco Limited is the only Canadian producer of primary magnesium. The company, located at Haley, Ontario, has produced magnesium by reducing a local dolomite with ferrosilicon (Pidgeon process), since 1942 and has an annual capacity of 10 800 tonnes (t). The plant also produces calcium and strontium metal using essentially the same equipment and materials. The purity of the magnesium produced by Chromasco can be as high as 99.95 per cent, which finds application in the chemical industry. A significant proportion of output is exported.

In 1980, production of magnesium in Canada was 8 899 t, about 1 per cent lower than in 1979 (9 015 t). Reported value of production was $27.04 million versus $24.44 million in 1979. Exports fell by 12 per cent to 5 316 t in 1980 and imports of primary metal and alloys increased by 18 per cent to 3 819 t. Canadian consumption in 1980 is estimated to have been in the order of 4 000 t. This was used mainly for aluminum alloying and a smaller quantity for castings.

Recovery of magnesium from asbestos tailings by Société nationale de l'amiante (SNA) in Quebec has been delayed until 1982 or until there is a definite improvement in market conditions for the metal. In the meantime the company is producing magnesium compounds on a small scale.

Cominco Ltd. began a feasibility study, in co-operation with Mitsui & Co., Ltd. of Japan, for the production of magnesium and ferrosilicon at Cominco's Kimberley, British Columbia plant, but no results were announced by year-end. Cominco has excess captive hydroelectric power capacity which would be used by the proposed plant.

WORLD REVIEW

World production of magnesium in 1980 is estimated at 320 400 t, about 4 per cent above the 308 200 t produced in 1979. World consumption in 1980 is estimated at 284 500 t, a slight decrease from that in 1979. The United States produced about 48 per cent of the total, followed by the U.S.S.R. with 23 per cent and Norway with 16 per cent. Canada accounted for 3 per cent.

Recycling is of moderate importance in magnesium, although data on amounts recovered are poor in most countries. Reported recoveries in 1980 were 36 700 t (in all forms) in the United States, 23 900 t in Japan and 3 300 t in EEC countries.

The United States produced approximately 154 000 t of magnesium metal in 1980, about 5 per cent more than in 1979. The four American producers have a capacity of 175 000 t, The Dow Chemical Company dominating with a capacity of 110 000 tpy. Dow, which uses seawater as its source of magnesium, plans to expand its annual capacity by another 12 000 t by 1982.

TABLE 1. CANADA, MAGNESIUM PRODUCTION AND TRADE, 1979 and 1980

	1979		1980P	
	(tonnes)	($000)	(tonnes)	($000)
Production[1] (metal)	9 015	24,444	8 899	27,037
Imports				
Magnesium metal				
United States	2 659	7,860	3 418	10,687
United Kingdom	10	82	2	53
Total	2 669	7,942	3 420	10,740
Magnesium alloys				
United Kingdom	179	1,622	167	2,195
United States	296	1,844	232	1,716
Denmark	3	8	-	-
Total	478	3,474	399	3,911
Exports				
Japan	1 364	3,476	1 548	4,223
United States	1 079	4,180	1 181	5,054
West Germany	1 805	4,807	975	2,757
United Kingdom	1 019	2,988	657	2,161
Switzerland	296	861	323	1,113
Australia	112	421	183	663
Poland	-	-	139	381
Netherlands	19	51	125	275
Israel	29	112	56	206
France	-	-	71	205
Uruguay	9	51	10	54
Sweden	-	-	10	42
Belgium-Luxembourg	-	-	17	39
India	2	7	6	26
Other countries	283	706	15	63
Total	6 017	17,660	5 316	17,262

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Magnesium metal in all forms and in magnesium alloys produced for shipment, less remelt.
P Preliminary; - Nil.

In December, N L Industries, Inc., which recovers magnesium from brine, completed the sale of its Rowley, Utah magnesium plant to AMAX Inc. Subsidiary Amax Specialty Metals Corporation announced its intention to increase annual capacity from the present 25 500 t to 40 800 t by 1982.

American Magnesium Company suspended operations at its Snyder, Texas plant in December, reportedly because the brine reservoirs were flooded, thus diluting the feedstock. The company's capacity is 10 000 tpy but it was not known whether the plant would reopen.

Northwest Alloys, Inc., an Aluminum Company of America (Alcoa) subsidiary, announced plans to increase its plant capacity from 22 000 t to 30 000 tpy for sometime in 1982. This plant uses the Magnetherm silicothermic reduction process.

Estimated consumption of magnesium in the United States was 86 898 t in 1980, a drop of 12 per cent from that in 1979. Usage fell in nearly every use category but particularly in aluminum alloys, cathodic anodes and chemicals. The poor showing was due mainly to the downturn in the economy and to a certain extent to the price of magnesium.

TABLE 2. CANADA, MAGNESIUM PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975-1980

	Production[1] Metal	Imports		Exports Metal		Consumption[2] Metal
		Alloys	Metal			
	(tonnes)	(tonnes)		(tonnes)	($)	(tonnes)
1970	9 392	232	1 847	6 957	5,562,000	4 477
1975	3 826	886	7 500	3 875	9,480,000	5 404
1976	6 092	684	1 128	3 397	7,450,000	4 230
1977	7 633	720	1 534r	4 320	10,497,000	6 222
1978	8 309	584	1 942	4 753	12,248,000	3 607
1979	9 015	478	2 669	6 017	17,660,000	4 066
1980P	8 899	399	3 420	5 316	17,262,000	..

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Magnesium metal in all forms and in magnesium alloys produced for shipments, less remelt.

[2] Consumption as reported by consumers.

P Preliminary; r Revised; .. Not available.

TABLE 3. CANADA, CONSUMPTION OF MAGNESIUM, 1975-1980

	1975	1976	1977	1978	1979	1980
	(tonnes)					
Castings and wrought products[1]	1 301	1 087	879	951	1 447	..
Aluminum alloys and other uses[2]	4 103	3 143	5 343	2 656	2 619	..
Total	5 404	4 230	6 222	3 607	4 066	..

Source: Energy, Mines and Resources Canada.

[1] Die, permanent mould and sand castings, structural shapes, tubing, forgings, sheet and plate. [2] Cathodic protection, reducing agents, deoxidizers and other alloys.

.. Not available.

The United States over the past five years has increased its exports of magnesium. In 1980, exports in metals and alloys in crude form rose by 4 per cent to 49 584 t. Canada imported 3 418 t from the U.S., most of which went into aluminum alloying. Larger quantities were shipped to Brazil, Japan, Netherlands and Mainland China.

In Norway, plans which had been reported last year to increase production by 50 per cent, have now been shelved until 1982.

Brazil is the fourth largest user of magnesium metal in the western world. All of its requirements to date have been imported. Brasiliera de Magnesio (Brasmag) is constructing a 5 000 tpy magnesium smelter in the Minas Gerais area, scheduled to come on stream in 1982. Another plant in the State of Rio Grande do Norte is being considered with production to start sometime in 1985 providing the feasibility study is positive.

Magnohrom Oour Bela Stena began production in January at its 5 400 tpy magnesium smelter at Baljevac Na Ibru in Serbia, Yugoslavia. It uses the Magnetherm silicothermic process.

In Italy, it was reported that increased electricity costs may cause the suspension of magnesium production by the Soc. Italiana Per il Magnesio at Bolzano. The company uses the ferrosilicon process with a capacity of 15 000 tpy, and had intended to increase capacity to 20 000 tpy.

Two magnesium companies in Japan produced 9 252 t of primary magnesium in 1980, down sharply from 11 368 t in 1979. Imports at about 12 500 t were little changed from 1979 and came mainly from the United States followed by Norway and Canada. Aside from depressed domestic markets, Japanese producers are suffering from rapidly rising electric power costs. Considerable quantities of secondary magnesium are also used in the production of titanium. Total Japanese consumption decreased by 6 per cent, mainly because of depressed aluminum production.

India reported that its first commercial scale magnesium plant was under construction at Valinekkam in Tamil Nadu state. The plant will have a capacity of 600 tpy.

TABLE 4. WORLD PRIMARY MAGNESIUM PRODUCTION, 1970, 1979 and 1980

	1970	1979P	1980^{e}
	(000 tonnes)		
United States^{e}	101.6	147.2	154.1
U.S.S.R.^{e}	49.9	71.7	75.3
Norway	35.3	44.2	44.4
Italy	7.6	8.7	9.7
Japan	10.3	11.4	9.3
France	4.6	9.0	9.3
Canada	9.4	9.0	8.9
Yugoslavia	-	0.5	1.9
China^{e}	1.0	6.0	7.0
Poland	-	0.5	0.5
Total	219.7	308.2	320.4

Sources: Annuaire Statistique Minemet; U.S. Bureau of Mines; Energy, Mines and Resources Canada.
P Preliminary; ^{e} Estimated.

USES

Magnesium's principal use is in alloying with other metals. Aluminum's strength and hardness is enhanced by the addition of magnesium. In the ferrous industry, magnesium is used as a deoxidizing and desulphurizing agent. Magnesium is used as a reducing agent in the preparation of titanium, zirconium and other reactive metals. Pure magnesium metal is used frequently for cathodic protection of steel structures. Increasing amounts of magnesium based alloys are being used in the foundry and diecasting industries. There are many uses for magnesium in the chemical industry including the making of Grignard reagents used in the production of tetrethyl lead for gasoline.

PRICES

The Canadian price of commercial grade magnesium (99.8 per cent pure) in carload lots fob Haley, Ontario was $1.35 a pound in 1980. Primary ingot prices in the United States, as quoted by **Metals Week**, increased in two stages from $US 1.09 to $1.25 and diecasting alloy AZ 91B similarly increased from $US 1.07 to $1.21.

United States magnesium prices, in United States currency, as quoted in **Metals Week**.

	¢/lb
Magnesium metal, in 10,000-lb lots:	
Primary ingot 99.8%	
January 1 to March 26, 1980	109.00
March 27 to September 30, 1980	116.00
October 1 to December 31, 1980	125.00
Diecasting alloy AZ91B ingot	
January 1 to March 26, 1980	107.00
March 27 to September 30, 1980	114.00
October 1 to December 31, 1980	121.00

OUTLOOK

Western world consumption of magnesium is expected to decrease in 1981 because of reduced steel and automobile production, but should recover in 1982 as economic activity improves in industrialized countries. The longer term outlook for magnesium consumption appears very favourable. Aluminum alloys will remain the major use but magnesium diecastings in automobiles offer important and growing potential. However, magnesium production is comparatively energy intensive and industry expansion will favour areas with competitive energy supplies. In this respect, various investors are investigating the feasibility of magnesium production in Canada, in some cases in conjunction with ferrosilicon and silicon production.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
35105-1	Magnesium metal, not including alloys, in lumps, powders, ingots or blocks	5	5	25	3
34910-1	Alloys of magnesium; ingots, pigs, sheets, plates, strips, bars, rods and tubes	4.9	4.9	25	3
34911-1	Magnesium alloy ingots, for use in the production of magnesium castings (from 1/3/78 to 30/6/81)	free	free	25	free
34912-1	Hardener alloys for use in the manufacture of magnesium castings (from 1/3/78 to 30/6/81)	free	free	25	free
34915-1	Magnesium scrap	free	free	free	free
34920-1	Sheet or plate, of magnesium or alloys of magnesium, plain, corrugated, pebbled, or with a raised surface pattern, for use in Canadian manufactures (expires 30/6/81)	free	free	25	free
34925-1	Extruded tubing, of magnesium or alloys of magnesium, having an outside diameter of five inches or more, for use in Canadian manufactures (expires 30/6/81)	free	free	25	free

MFN Reductions under GATT (effective January 1 of year given)

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
						(%)			
35105-1	Magnesium metal, not including alloys, in lumps, powders, ingots or blocks	5.0	5.0	4.8	4.7	4.5	4.3	4.2	4.0
34910-1	Alloys of magnesium; ingots, pigs, sheets, plates, strips, bars, rods and tubes	4.9	4.8	4.6	4.5	4.4	4.3	4.1	4.0

TARIFFS (cont'd)

UNITED STATES

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
						(%)			
628.55	Magnesium, unwrought, other than alloys; and waste and scrap	19	18	16.5	15	13.5	12	10	8
628.57	Magnesium, unwrought alloys, per pound of magnesium content	7.3	7.2	7.1	7	6.8	6.7	6.6	6.5
628.59	Magnesium metal, wrought, per pound of magnesium content	¢ per lb. of magnesium content plus %							
		6.2¢ 3.4%	6.0¢ 3.3%	5.7¢ 3.1%	5.5¢ 3.0%	5.2¢ 2.9%	5.0¢ 2.8%	4.7¢ 2.6%	4.5¢ 2.5%

Sources: The Customs Tariff and Commodities Index, Revenue Canada; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States Annotated (1980), USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241.

Manganese

D.G. LAW-WEST

Manganese is essential in the production of nearly all types of steel and approximately 95 per cent of all manganese produced is consumed by the iron and steel industry. Accordingly, the demand for manganese ores is essentially determined by the world production of iron and steel. Manganese is considered to be a strategic commodity because of its critical role in iron and steel making, for which there are no acceptable substitutes.

CANADA

Canada has no domestic producers of manganese ore although several low-grade deposits have been identified in Nova Scotia, New Brunswick and British Columbia. The largest of these deposits, located near Woodstock, New Brunswick is reported to contain about 45 million tonnes (t) of mineralization grading 11 per cent manganese and 14 per cent iron. Although processes have been developed to utilise such low-grade deposits, commercial production is unlikely to be economic at current manganese prices.

The two ferromanganese producers in Canada: Union Carbide Canada Limited (UCC) and Chromasco Limited, use imported metallurgical-grade manganese ore as feed material. These companies have plants at Beauharnois, Quebec and both sell their production mainly to domestic steel producers.

In mid-1980 Union Carbide Corporation of the United States announced plans to sell some of its ferroalloy plants, including those producing ferromanganese and silico manganese in the United States, Canada and Norway. However, negotiations between Union Carbide and the consortium of Elkem-Spigerverket A/S (Norway), Sheilding Investments (Canada) and other unnamed Norwegian investors had not been finalised by the end of the year.

Canada also imports manganese metal, an important additive in specialty steels as well as in aluminum alloys. The main consumers of manganese metal are Atlas Steels, a Division of Rio Algom Limited, Aluminum Company of Canada, Limited and Reynolds Aluminum Company of Canada Ltd.

High-purity manganese dioxide and battery-grade manganese ores are imported into Canada by various companies including Duracell Inc., Gould Manufacturing of Canada, Ltd. (Industrial Battery Division), Cominco Ltd. and Canadian Electrolytic Zinc Limited.

WORLD DEVELOPMENTS

World manganese ore production in 1980, at some 23 million t, was slightly lower than the 1979 production of 24.5 million t.

South Africa continued to be the largest manganese ore supplier in the western world in 1980. Three companies consisting of SA Manganese Amcor Ltd. (Samancor), Associated Manganese Mines of South Africa Ltd. (Ammosal) and Anglo American Corporation of South Africa Ltd. were the major producers of South African metallurgical-

TABLE 1. CANADA, MANGANESE, TRADE AND CONSUMPTION, 1979 AND 1980

	1979		1980^p	
	(tonnes)	($000)	(tonnes)	($000)
Imports				
Manganese in ores and concentrates[1]				
Gabon	9 552	1,479	36 346	6,577
South Africa	-	-	23 508	2,994
Brazil	10 996	1,832	15 360	2,977
United States	5 182	1,889	8 010	2,590
Fr. Africa, nes	18 935	2,970	11 937	2,432
Other countries	485	177	-	-
Total	45 150	8,347	95 161	17,570
Manganese metal				
South Africa	7 811	8,326	6 413	7,775
United States	246	212	440	690
Other countries	217	311	103	136
Total	8 274	8,849	6 956	8,601
Ferromanganese, including spiegeleisen[2]				
South Africa	22 129	12,366	12 284	5,946
Norway	5 042	3,307	9 468	5,103
United States	19 505	11,809	4 792	3,777
France	68	84	102	133
Sweden	-	-	36	69
Mexico	794	338	20	10
West Germany	-	-	2	1
Brazil	10 500	5,118	-	-
Other countries	25 662	12,269	-	-
Total	83 700	45,291	26 704	15,039
Silicomanganese, including silicospiegeleisen[2]				
United States	12 080	7,054	12 089	7,995
Norway	6 776	3,552	4 050	2,430
Other countries	3 021	1,740	4 763	3,013
Total	21 877	12,346	20 902	13,438
Exports				
Ferromanganese[2]				
United States	11 962	2,767	11 189	3,753
Malaysia	-	-	53	29
Jamaica	81	63	-	-
Other countries	-	-	36	20
Total	12 043	2,830	11 278	3,802
Consumption				
Manganese ore				
Metallurgical grade	61 643	..	..	..
Battery and chemical grade	3 056	..	..	..
Total	64 699	..	..	..

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Mn content; [2] Gross weight.
^{p} Preliminary; - Nil; .. Not available; nes Not elsewhere specified.

grade ores. Their combined output in 1980 was estimated to be over 6.5 million t.

The Australian producer, Groote Eylandt Mining Company Proprietary Ltd. (Gemco), owned by Broken Hill Proprietary Company Limited (B.H.P.), announced plans to increase manganese ore production by 180 000 tpy in 1982. The capital cost of the new plant will be about $US 15 million. Gemco's present capacity is over 2 million tpy.

In Gabon, the completion of the Trans Gabon railway was delayed until 1986-87. This delay will probably limit exports of manganese from Gabon to 2.0-2.5 million tpy, the capacity of the present transportation system. Ore from the Moanda mine is transported via a 76 kilometre (km) cableway to the border of the Congo Republic where it is then transferred to railcars and shipped 486 km to the port of Pointe Noire for boat loading. Production at the mine is expected to double to about 5 million tpy when the Trans Gabon railway is completed.

Sinai Manganese Co. of Egypt has awarded a contract for a feasibility study to Kaiser Engineers Inc., a subsidiary of Raymond International Inc. The study will examine the potential of the manganese resources of the Sinai area to support mining and ferromanganese production.

USES

The excellence of manganese as a desulphuriser has made this metal an irreplaceable input in the steel industry. Steels containing excess sulphur are not homogeneous and tend to crack and tear during rolling and forming. Manganese combines with the sulphur to produce a manganese sulphide slag which is readily separated from the steel. The metal also acts as a deoxidiser during the steelmaking process.

Manganese is usually added to steel in the form of a ferroalloy such as ferromanganese or silicomanganese. Steel mills in Canada use about 5.8 kilograms (kg) of manganese per t of crude steel produced.

Specialty steels frequently contain manganese to increase strength and hardness. Manganese metal is normally used in preference to ferromanganese in making these specialty steels because it provides better control of the manganese and impurities content.

Hadfield steel, a type of specialty steel, contains between 10 and 14 per cent manganese. These steels are extremely hard and tough, and are particularly suited for applications such as rock crusher parts and teeth in earth-moving machinery.

TABLE 2. CANADA, MANGANESE IMPORTS, EXPORTS AND CONSUMPTION, 1970, 1975-80

	Imports			Exports	Consumption	
	Manganese Ore[1]	Ferro-Manganese	Silico-Manganese	Ferro-Manganese	Ore	Ferromanganese and Silicomanganese
	(gross weight, tonnes)					
1970	115 052	17 891	975	510	153 846	97 952
1975	69 773	35 701	5 732	1 168	160 976	95 869
1976	118 972	25 098	12 056	9 861	238 629	83 687
1977	57 644	29 404	4 835	23 104	182 157	82 467
1978	136 446	26 812	15 842	19 924	201 320	69 349
1979	45 150	83 700	21 877	12 043	64 699	89 429
1980p	95 161	26 704	20 902	11 278	..	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Mn content.
p Preliminary; .. Not available.

Iron used for castings is desulphurized with manganese. Otherwise, the sulphur causes surface imperfections and makes precision casting difficult.

Also, manganese is used to form alloys with nonferrous metals: aluminum-manganese alloys are noted for their strength, hardness and stiffness; manganese-magnesium alloys are hard, stiff and corrosion resistant; and manganese bronzes have properties desirable in specific applications such as ship propellers.

Manganese has many nonmetallurgical applications including its use in dry-cell batteries. In this role manganese dioxide provides oxygen to combine with hydrogen, which permits the battery to operate at maximum efficiency. Manganese ores used for batteries must grade above 85 per cent manganese dioxide and have a low iron content. Very few natural manganese dioxide ores can meet these specifications, and thus most batteries contain a blend of natural ore and synthetic manganese dioxide.

A common classification of manganese ore gives rise to the following ore types: (1) Manganese ores containing more than 35 per cent manganese: These are used in the manufacture of both low- and high-grade ferromanganese. Although battery-grade ores are included in this class, these ores must contain no less than 85 per cent manganese dioxide. (2) Ferruginous manganese ores containing 10 to 35 per cent manganese and used in the manufacture of spiegeleisen. (3) Manganiferous iron ores containing 5 to 10 per cent manganese and used to produce manganiferous pig iron.

All types of manganese ores can be employed in the production of manganese chemicals such as: potassium permanganate, a powerful oxidant used in the purification of public water supplies; manganese oxide, an important addition to welding rods and fluxes; and an organometallic form of manganese, which inhibits smoke formation and improves the combustion of fuel oil. Various manganese chemicals are employed to produce colour effects in face bricks and, to a lesser extent, to colour or decolour glass and ceramics.

TABLE 3. WORLD PRODUCTION OF MANGANESE ORES, 1977-79

	Mn	1977	1978	1979p
	(%)		(000 tonnes)	
U.S.S.R.	35	8 591	9 058	9 526
Republic of South Africa	30-48+	5 048	4 318	5 182
Gabon	50-53	1 851	1 661	1 815
Brasil	38-50	1 516	1 633	1 701
Australia	37-53	1 389r	1 290	1 666
India	10-54	1 866	1 567	1 633
People's Republic of Chinae	20+	999r	1 270	1 497
Mexico	35+	487	524	545
Ghana	30-50	292r	316	273
Morocco	33-50	114	126	136
Hungary	30-33	120r	115	105
Argentina	25-30	83r	98	91
Japan	26-22	126	107	91
Bulgaria	25-30	49r	40	40
Turkey	35-46	19r	20	30
Zaire[1]	..	150	-	-
Other countries[2]	..	128r	194	129
Total	..	22 819	22 337	24 460

Source: U.S. Bureau of Mines, **Mineral Yearbook**, 1978-79.

[1] Production for Zaire is from **World Mining Yearbook, Catalogue and Survey Directory**, 1980.
[2] Includes 13 countries, each producing less than 30 000 tpy.
p Preliminary; e Estimated; r Revised; .. Not available; - Nil.

PRICES

Contract negotiations for 1980 ore delivery followed a pattern similar to those in 1979. Ore producers were seeking price increases of about 40 cents a long ton unit (ltu) to offset increased transportation cost. However, consumers were reluctant to grant any increase because of their large inventory holdings. Most contracts were finalized in late March when the parties agreed to increase ore prices to $1.66 - $1.75 per ltu from the 1979 price range of $1.38 - $1.42.

OUTLOOK

The outlook for manganese is closely linked to steel production forecasts since 95 per cent of manganese produced is used by the steel industry.

The short-term demand for manganese is forecast to continue in a depressed state because of the slow recovery expected in the world steel industry. Large consumer inventories of manganese ore and ferromanganese at year-end indicated that contract negotiations for 1981 ore delivery could be somewhat more difficult than in 1980 when producers gained a 20 per cent price increase.

There is a growing trend in expanding ferroalloy production capacity in ore-producing countries because oil price increases deter the shipping of low value-to-bulk cargoes, particularly to countries which are also dependent on oil for the electrical power used in their ferroalloy industries.

In the longer-term, the rising consumption of coals with higher sulphur content will tend to increase the amount of manganese required in steelmaking. However, technological improvements in desulphurization could offset this trend.

PRICES

United States prices in U.S. currency, as published by **Metals Week**

	December 1979	December 1980
	(cents)	(cents)
Manganese ore, per long ton unit (22.4 lb) cif U.S. ports, Mn content		
Min. 48% Mn (low impurities)	138.00-142.00	166.00-175.00
Ferromanganese, fob shipping point, carload lots, lump, bulk	($)	($)
Standard 78% Mn, per long ton	490.00-530.00	490.00-530.00
	(cents)	(cents)
Medium-carbon, 80-85% Mn, per lb Mn	46.00	46.00
Silicomanganese, per lb of alloy, fob shipping point, 65-68% Mn, 16-18.5% Si, 0.2% P, 2% C	24.50	24.50
Manganese metal, per lb of product, fob shipping point		
Regular, minimum 99.5% Mn	62.00	70.00
6% N, minimum 93.7% Mn	63.25-65.00	70.00-80.00

fob Free on board; cif Cost, insurance and freight.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
32900-1	Manganese ore	free	free	free	free
33504-1	Manganese oxide	free	free	free	free
35104-1	Electrolytic manganese metal	free	free	20%	free
37501-1	Ferromanganese, spiegeleisen and other alloys of manganese and iron, not more than 1% Si, on the Mn content, per lb.	free	0.5¢	1.25¢	free
37502-1	Silicomanganese, silicospiegel and other alloys of manganese and iron more than 1% Si, on the Mn content, per lb.	free	0.75¢	1.75¢	free

MFN Reductions under GATT (effective January 1 of year given)

	1980	1981	1982	1983	1984	1985	1986	1987
				(cents)				
37501-1	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4
37502-1	0.75	0.75	0.74	0.73	0.74	0.72	0.71	0.70

UNITED STATES (MFN)

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
				(%, unless otherwise specified)					
601.27	Manganese ore, including ferruginous manganese ore and manganiferous iron ore, all the foregoing containing over 10 per cent by weight of manganese	free	free	free	free	free	free	free	free
606.26	Ferromanganese, not containing over 1% C	0.3¢/ lb + 2%	0.3¢/ lb + 2%	2.6	2.6	2.5	2.4	2.4	2.3
606.28	Ferromanganese containing 1 to 4% C, per lb. manganese content	0.46¢	0.46¢	1.4	1.4	1.4	1.4	1.4	1.4
606.30	Ferromanganese containing over 4% C, per lb. manganese content	0.3¢	0.3¢	1.6	1.6	1.6	1.5	1.5	1.5
632.28	Manganese metal waste and scrap	13.0[1]	11.9[1]	10.9	9.8	8.8	7.7	6.7	5.6
632.30	Manganese metal, unwrought	14.0		remains free					

Sources: The Customs Tariff and Amendments, Revenue Canada, Customs and Excise Division, Ottawa; Notice of Ways and Means Motion, Customs Tariff, Department of Finance, Ottawa, 1979; Tariff Schedules of the United States (TSUS) Annotated 1978, TC Publication 843; U.S. Federal Register Vol. 44, No. 241.

[1] Duty temporarily suspended.

Mercury

J.J. HOGAN

There has been no mine output of mercury in Canada since July 1975 when the Pinchi Lake mine of Cominco Ltd., located 48 kilometres (km) north of Fort St. James, British Columbia, suspended operations indefinitely. The mine's closure resulted from a significant decline in mercury prices caused by a sharp drop in demand for the metal. The Pinchi Lake property is being kept on standby pending an improvement in demand and price.

Canadian imports of mercury metal in 1980 were 50 000 kilograms (1,450 flasks[1]), compared with 50 711 kg (1,471 flasks) in 1979. Statistics on consumption of mercury metal are incomplete but usage by those companies reporting consumption totalled 36 326 kg (1,053 flasks) in 1980, compared with 26 249 kg in 1979.

WORLD REVIEW

The United States Bureau of Mines (USBM) estimated world production of mercury at 6 556 700 kg in 1980, compared with 6 647 900 kg in 1979. The U.S.S.R. is by far the world's largest mine producer of mercury. Its production in 1980 is considered to have been about the same as the 1979 level, which has been estimated at 2 102 853 kg. The United States, the world's second-largest producer in 1980, had an output of 1 047 841 kg of mercury. Following close behind the United States were Spain and Algeria, each with an estimated production of 1 034 190 kg. Other countries which produced a significant amount of mercury were the People's Republic of China, Czechoslovakia and Turkey. The mercury mines of Italy, Yugoslavia and Canada have been substantial contributors to the world's output in the past, but operations at these mines have been suspended pending market improvements. Mexico has drastically lowered its output, and in 1980 produced only 51 710 kg of mercury.

The Almaden mine of Minas de Almadén in Spain is one of the largest producers of mercury in the non-communist world. Output at the Almadén mine in 1980 was estimated to be about 50 per cent of its normal annual capacity of 2 068 000 kg. The company is preparing a new mine, El Entredicho, located about 17 km from the present plant, for production by late 1981 or early 1982. The ore is reported to be higher grade than that being mined at Almadén. Ore will be mined by open-pit methods and treated in existing furnaces. When the open-pit mine comes onstream Minas de Almadén will be able to produce 1 724 000 kg of mercury; 1 034 000 kg from the open-pit, 345 000 kg from the present underground workings and 345 000 kg from a nearby subsidiary mine. By 1985 it is expected most of Almadén's ore will come from the open-pit operation.

In October, the Spanish parliament passed a bill providing for the transfer of Consejo de Administracion de Minas de Almadén from an autonomous government department into an independent nationalized company. Prior to this, Almadén came under the jurisdiction of the Spanish finance department. This move is expected to give Almadén more flexibility in handling the technical problems of the operations and in the diversification of the company into other areas such as prospecting for other metals.

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[1] One flask equivalent to 34.473 kg.

United States production of mercury in 1980 was 1 047 841 kg, slightly higher than the 1 017 608 kg produced in 1979. Mercury production came from two mines, one in Nevada and one in California, but the McDermitt mine in northwestern Nevada accounted for most of the production. The McDermitt operation is a joint venture in which Placer Amex Inc., a wholly owned subsidiary of Placer Development Limited of Vancouver, has a 51 per cent interest and Minerals Exploration Company of New Jersey has the remaining 49 per cent.

Reports indicate that Italy's Monte Amieta mine may resume production in response to the improved price of the metal. The mine, a substantial producer in the past, was closed in 1976 because of rising costs and falling prices. Mercury sales made after this period were from stocks. Yugoslavia plans to reopen its Idrija Mine, also a former substantial mercury producer.

Japan is not at present a primary producer of mercury but has a large stock obtained from caustic soda plants following a change in techniques away from the use of mercury. Stocks are estimated to be 2 068 380 kg and a further 999 717 kg will be available with the conversion of remaining caustic soda plants. Japan's large stockpile of mercury is available for export but metal reportedly will be released in such a manner as to avoid disrupting the market.

The United States is the largest non-communist consumer of mercury and in recent years has produced less than its requirements. The USBM reported total mercury consumption by the United States at 2 033 321 kg in 1980, an increase of about 30 per cent over the 1 566 522 kg consumed in 1979. Most of the increase was attributable to greater usage in batteries. The shortfall between primary production and consumption was made up by mercury

TABLE 1. CANADA, MERCURY PRODUCTION, TRADE AND CONSUMPTION, 1979 AND 1980

	1979		1980P	
	(kilograms)	($)	(kilograms)	($)
Mine Production	-	-	-	-
Imports (metal)				
United States	21 410	190,000	43 000	497,000
Japan	-	-	7 000	92,000
Spain	23 269	261,000	-	-
Puerto Rico	5 080	41,000	-	-
Netherlands	907	10,000	-	-
United Kingdom	45	...	-	-
Total	50 711	502,000	50 000	589,000
Consumption[1] (metal)				
Heavy chemicals	3 237	..	9 682	..
Electrical apparatus	15 834	..	3 041	..
Gold recovery	379	..	334	..
Miscellaneous	6 799	..	23 269	..
Total	26 249	..	36 326	..

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Available data, as reported by consumers.
P Preliminary; - Nil; .. Not available; ... Less than $500.

from secondary sources and imports. Imports totalled 324 598 kg in 1980, well below the 993 443 kg imported in 1979. Japan and Spain were the major suppliers of mercury to the United States in 1980, accounting for 131 446 kg and 115 553 kg, respectively. Imports from Canada and Mexico were relatively small.

Statistics on world consumption of mercury in 1980 are not available but consumption is believed to have fallen in Europe. However, consumption in China and the U.S.S.R. is believed to have increased. Total world consumption probably slightly exceeded 1980 production of 6 556 765 kg. Some mercury is available from secondary sources and stocks.

In 1975, many of the world's major producers, (i.e., Spain, Turkey, Yugoslavia, Algeria and Peru) established the International Association of Mercury Producers (ASSIMER) with headquarters in Geneva. At that time, member countries accounted for about 90 per cent of non-communist exports of mercury. Canada and the United States did not join the organization.

The major objectives of the Association are to stabilize prices by controlling production or by withholding supplies from the market during periods of low demand, to develop new uses for mercury, and to improve the environmental situation of mercury. Meetings are held at least once a year to discuss the world's mercury situation and to determine what action is necessary to ensure a viable market. Generally ASSIMER does not make known the subjects discussed at these meetings, but it is believed that price-setting was the major topic of the meetings held in 1980.

TABLE 2. CANADA, MERCURY PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975-1980

	Production, Metal	Imports, Metal	Consumption, Metal
		(kilograms)	
1970	841 141	69 536	154 474
1975	413 676	73 527	32 869[1]
1976	-	62 641	26 039[1]
1977	-	21 908	30 447[1]
1978	-	43 046	29 904[1]
1979	-	50 711	26 249[1]
1980P	-	50 000	36 326[1]

Sources: Energy, Mines and Resources Canada; Statistics Canada; 1970 metal production is obtained directly from Cominco Ltd. and represents output from Pinchi Lake mine in British Columbia.

[1] Available data, as reported by consumers.
P Preliminary; - Nil.

At the end of 1980, the United States strategic and critical materials stockpile contained a total of 6 597 822 kg (191,391 flasks). The stockpile goal has been lowered considerably from a year ago and is now 361 966 kg (10,500 flasks). The declared surplus stocks cannot be released without authorization by the United States Congress. Surplus mercury released by other government agencies and totalling 345 178 kg (10,013 flasks) was auctioned on a monthly basis in 1980 by the General Services Administration. Stocks held by United States producers, consumers and dealers on December 31, 1980 were 1 139 988 kg (33,069 flasks), compared with 950 834 kg (27,582 flasks) at the end of December 1979.

USES

Mercury's two major uses in recent years have been in the manufacture of electrical apparatus and in the electrolytic production of chlorine and caustic soda, although the use in the latter application is declining. Together these two applications accounted for about 52 per cent of mercury consumed in the United States in 1980. Electrical uses include mercury lamps, batteries, rectifiers, bulbs, oscillators and various kinds of switches, including silent switches for use in residences. Because mercury lamps are more adaptable to higher voltage supply lines than are incandescent lamps, they are widely used for industrial and street lighting purposes. The mercury battery, invented in 1944, has a relatively long shelf life and can withstand high temperatures and high humidity. It is widely used in portable metering, photography, and communication devices where reliability is important.

Other applications of mercury are in mildew-proofing paints, industrial and control instruments, pharmaceuticals, insecticides, fungicides, bactericides and dental preparations, although in some countries some of these uses have been restricted or banned by governments. Several mercury compounds, especially the chloride, oxide and sulphate, are good catalysts for certain chemical reactions, including those involved in the making of plastics. Because of its capacity to absorb neutrons, the metal has been used as a shield against atomic radiation. New technologies could open up new areas of use in the nuclear, metal-chloride vapour, plastic, chemical, amalgam and ion exchange fields. Substitutes for mercury include nickel-cadmium or other battery systems for use in electrical apparatus, diaphragm cells for mercury cells in the chlor-alkali industry, organotin compounds in paint, and solid-state devices for industrial and control instruments.

ENVIRONMENTAL REGULATIONS CONCERNING MERCURY

In 1973, the United States Environmental Protection Agency (EPA) published the final air emission standard for mercury at 2 313 grams (g) per day, per plant, released to the atmosphere. In 1974, EPA proposed an amendment to the emission standard for hazardous air pollutants in which mercury emissions from the incineration and drying of waste water treatment plant sludges would be limited to a maximum of 3 200 g per day. Further, the National Institute for Occupational Safety and Health submitted criteria for a recommended standard on the occupational exposure to inorganic mercury. In 1975, EPA proposed National Interim Primary Drinking Water Regulations and held hearings on them. Comments and information were received from representatives of state agencies, public interest groups and others. The regulations proposed maximum contaminant levels in public drinking water and set the mercury level at 0.002 milligrams per litre.

In March 1974, the EPA promulgated its final effluent limitation guidelines for existing and new sources in the inorganic chemicals manufacturing category. The daily limitation is 0.000 28 g of mercury per 1 000 g of effluent for mercury-cell plants in existence in operation prior to March 1974, and half this level for newer plants. One of the stated goals of the Federal Water Pollution Control Act of 1972 is the elimination of all pollutant discharges by 1985.

In 1975, EPA concluded its hearings on the proposed cancellation of biocidal uses of

TABLE 3. WORLD PRODUCTION OF MERCURY, 1976, 1979 AND 1980

	1976	1979P	1980^e
		(kilograms)	
U.S.S.R.^{e}	1 930 488	2 102 853	..
United States	797 464	1 011 541	1 144 504
Spain	1 472 997	1 206 555	1 034 190
Algeria	1 065 733	1 034 190	1 034 190
People's Republic of China	896 298	689 460	..
Czechoslovakia	213 733	217 180	..
Turkey	168 883	172 365	..
West Germany	110 003	86 183	..
Mexico	517 991	68 946	51 710
Finland	13 203	41 368	..
Dominican Republic	-	17 236	..
Australia	138	69	..
Italy	767 990	-	..
Yugoslavia	431 016	-	..
Other countries	448	-	3 292 170
Total	8 386 385	6 647 946	6 556 760

Sources: Preprint from the 1978-79 U.S. Bureau of Mines, Minerals Yearbook for 1976 and 1979 statistics; U.S. Bureau of Mines, Mineral Commodity Summaries, 1981 for 1980 statistics.
P Preliminary; ^{e} Estimated; .. Not available, but estimate included in figure for "Other countries"; - Nil.

TABLE 4. UNITED STATES MERCURY CONSUMPTION BY USES, 1976, 1979 AND 1980

	1976	1979	1980P
	(kilograms)		
Agriculture[1]	20 925	..	..
Catalysts	43 574	18 891	8 756
Dental preparations	68 601	27 337	..
Electrical apparatus[2]	947 939	403 748	235 968
Electrolytic preparation of chlorine and caustic soda	553 430	419 881	329 596
General laboratory use	20 511	14 134	3 827
Industrial and control instruments	174 675	124 206	139 271
Paint	270 441	344 006	222 144
Pharmaceuticals	2 068	..	..
Other[2]	100 661	214 319	310 188
Total known uses	2 202 825	1 566 522	1 249 750
Total unknown uses	33 439	-	76 737
Grand total[3]	2 236 264	1 566 522	1 326 487

Sources: Preprint from the 1978-79 U.S. Bureau of Mines, Minerals Yearbook for 1976 statistics; U.S. Bureau of Mines, Mineral Industry Surveys, "Mercury in the Third Quarter of 1980" for 1979 statistics; U.S. Bureau of Mines, Mineral Industry Surveys, "Mercury in the Fourth Quarter 1980" for 1980 statistics.

[1] Includes fungicides and bactericides for industrial purposes. [2] Includes mercury used in the manufacture of chemicals and allied products and lubricating oils. [3] The individual items do not add to the total which has been increased to cover approximate total consumption. P Preliminary; .. Not available; - Nil.

mercury, including mildewcides in paint. Early in 1976, the agency ordered an immediate halt to the use of mercury compounds in pesticides. Later in the same year, EPA rescinded its ban on the use of mercury compounds in some agricultural products and postponed the ban for other uses. The use of mercury in winter disease control products for golf courses was reinstated permanently. EPA also reinstated the use of mercury compounds in latex (water-based) paints, but continued the ban on their use in non-water-based paints. The agency also requested a review of the uses of mercury in other pesticides.

In Canada, the federal "Chlor-Alkali Mercury Regulations", which became effective in May 1972, restrict the quantity of mercury that may be discharged in the effluent from any chlor-alkali plant using the mercury-cell process. They stipulate that mercury in liquid effluent deposited in any one day in waters frequented by fish, shall not exceed 2.5 g/t of chlorine produced by the plant in that day.

Also in Canada, the federal Food and Drugs Act is designed, among other things, to protect Canadians against health hazards related to foods. The Act is administered by the Health Protection Branch of the Department of National Health and Welfare. Section 4(a) of the Act provides legal authority for the branch to determine those levels in foods of substances, such as mercury, which are considered to represent a hazard to human health, and to prohibit the sale of foods containing unsafe levels of the substances in question. After a study of the available data on the toxic effects to humans of mercury-contaminated fish, the consumption of fish by Canadians, and action taken by other countries on this matter, the Health Protection Branch decided in 1969 that, as a temporary measure, it would not object to the sale of fish containing not more than 0.5 parts per million (ppm) of mercury determined on a wet basis. In effect, this 0.5 ppm mercury level represents an administrative guideline applicable to fish only, and is legally binding only at the point of sale. Apparently this same 0.5 ppm mercury level in fish was subsequently adopted by the United States government authorities.

OUTLOOK

Historically, the performance of the mercury market has been erratic. It is considered that the producers association (ASSIMER) has

TABLE 5. AVERAGE MONTHLY PRICES OF MERCURY IN 1980 AT NEW YORK AND CIF MAIN EUROPEAN PORT

		cif main European port[2]	
	New York[1]	Low	High
	($US/flask)		
January	378.636	384.375	395.750
February	390.000	386.667	400.000
March	393.810	390.000	402.500
April	402.045	399.250	410.000
May	389.524	388.333	400.000
June	381.429	381.250	392.500
July	389.318	393.778	404.889
August	387.619	402.750	413.250
September	394.048	412.000	418.000
October	404.773	410.667	418.778
November	389.529	392.750	403.625
December	363.636	369.750	381.875

Sources: **Metals Week**; **Metal Bulletin** (London).
[1] Consensus of fixed price prompt sales of 20 or more flasks of prime virgin metal in the United States. Price includes delivery, United States import duty, plus any applicable surcharges. [2] Prices are cif main European port, minimum 99.99 per cent.
cif: Cost, insurance and freight.

brought a degree of stability to the market through better control of production, sales and prices. The price was comparatively stable in 1980 and this stability, combined with a sharp price increase in 1979, has led to some former producers giving consideration to reopening their mines. Prospects of these mines reopening or new mines coming into production should constrain any sharp price increases in 1981.

With ample mercury stocks in the hands of producers, consumers and dealers, and with many of the recently closed mines on a standby basis, adequate supplies should be assured in the short- to medium-term. No problems are envisaged in meeting the demand for mercury in the longer-term. Consumption is not expected to change greatly from the present level but should show a small upward trend. Declining demand for mercury in the chlor-alkali industry should be more than offset by increased demand in electrical apparatus and industrial control instruments, applications which are not expected to be affected to any degree by substitutes. Recycled mercury, especially from the chlor-alkali plants which no longer use mercury in their process, will play an important role in supply. Also overhanging the market is the surplus mercury in the United States strategic stockpile. The United States Congress has to approve sales of this surplus stock before sales can be made but, when or if approval is given, it is expected sales will be conducted in such a manner as to not significantly affect normal market operations.

PRICES

Many of the world's major mercury producers continued to restrict sales of mercury in 1980 to stabilize world prices. Minas de Almadén of Spain is one of the leaders in determining the price structure. The price was comparatively stable throughout the year as shown in Table 5, varying from an average monthly low of $US 10.55 per kg in December to a high of $11.74 per kg in October. The opening **Metals Week** quote was $US 10.73-$11.02 per kg. European traders set their price at $12.04 per kg. The price moved up slightly in March when the producers decided to set their price at $12.04 per kg. In mid-May the price declined because European dealers lowered their inventories. The price firmed again in late June when Almadén announced its price was to be increased to $12.47 per kg. In late September, Almadén raised its price to $12.90 kg which helped strengthen the world price. In mid-November, the mercury price began a downward trend on a surplus of mercury being offered from China and the U.S.S.R. The closing **Metals Week** price for the year 1980 was $10.44-$10.73 per kg.

The average dealer price of mercury in New York, for 1980 as quoted in **Metals Week**, was $US 11.297 per kg ($389.45 per flask), compared with $8.15 per kg ($201.10 per flask) in 1979, an increase of over 38 per cent. The cif main European port price, as quoted in **Metal Bulletin** London, ranged from a low of $U.S. 10.59 per kg ($365 per flask) on December 22 to a high of $12.04 per kg ($415 per flask) on October 16.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
92805-2	Mercury metal	free	free	free	free
92828-4	Mercuric oxide for manufacture of dry-cell, primary batteries (expires February 28, 1981)	free	free	25%	free

UNITED STATES

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
					(cents per pound)				
601.30	Mercury ore	Remains free							
632.34	Mercury metal, unwrought and waste and scrap[1]	11.9	11.3	10.6	10.0	9.4	8.8	8.1	7.5

EUROPEAN ECONOMIC COMMUNITY: (MFN)

Item No.		1980	Base Rate	Concession Rate
28.05	Mecury, in flasks of a net capacity of 34.5 kg, of a f.o.b. value, per flask, not exceeding 224 EUA[2]	6.72 EUA per flask		
28.28	Mercury oxides	5.4%	5.6%	4.1%

Sources: The Customs Tariff and Commodities Index, Revenue Canada, Tariff Schedules of the United States Annotated 1980, USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 22, No. L342, 1979.

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[1] The suspension of duty on waste and scrap was extended until June 30, 1981.

[2] EUA - European unit of account.

Molybdenum

D.G. FONG

In contrast to the tight supply pattern of the past seven years, molybdenum supply in the western world exceeded demand in 1980. Western world consumption of molybdenum during 1980, estimated at 73 000 tonnes (t), decreased by 12 per cent, while production increased by 6 per cent to about 98 000 t. The increase in production was primarily due to the resumption of operations after a prolonged labour strike during 1979 at the major Canadian molybdenum mines.

The decline in consumption resulted from the economic recession in the United States and a slowdown in European economies. The steel industry, the major consumer of molybdenum, was particularly hampered by the economic recession. Molybdenum markets softened as a result and prices trended downward, especially in the merchant market. Prolonged strikes at byproduct molybdenum operations in the United States during 1980 did little to reverse the market trend.

In spite of the soft market in 1980, major molybdenum producers proceeded with new mine development programs. Considerable new capacity will be brought on-stream during the next half-decade, predominantly in the United States, Canada, and Mexico. The forecast increase in molybdenum output will probably create an oversupply situation worldwide for the next few years.

CANADA, PRODUCTION, TRADE AND CONSUMPTION

Canadian molybdenum production in 1980 was 15 452 t, up 54 per cent from 1979. The production increase was primarily due to the resumption of operations at the major Canadian molybdenum mines after prolonged labour strikes in 1979, and improved metal recoveries in response to recent high molybdenum prices.

Production by Placer Development Limited at the Endako mine, which represents more than 47 per cent of total Canadian molybdenum output, returned to normal operation in the first quarter of 1980 after an eight and one-half month strike that ended on November 1, 1979. Following settlement of the strike, Placer declared a 50 per cent force majeure on molybdenum deliveries, which was eased to 30 per cent on January 1, and to 10 per cent on February 15, 1980. The force majeure was lifted on April 1, 1980. Construction of a lubricant plant at the Endako mine has been completed and production of high purity lubricant-grade molybdenum disulphide began late in October, 1980 at a rate of 453 tonnes per year (tpy). The company is also installing another roaster at the mine site which, when completed in 1981, will enable Endako to treat concentrates on a toll basis.

TABLE 1. CANADA, MOLYBDENUM PRODUCTION, TRADE AND CONSUMPTION, 1979 AND 1980

	1979		1980P	
	(kilograms)	($)	(kilograms)	($)
Production (shipments)[1]				
British Columbia	10 766 492	321,228,104	11 466 000	296 932,000
Quebec	408 094	10,796,316	732 000	18,491,000
Total	11 174 586	332,024,420	12 198 000	315,423,000
Exports				
Molybdenum in ores, concentrates and scrap[2]				
Japan	2 261 600	76,128,000	4 033 000	113,468,000
Belgium-Luxembourg	2 925 600	34,645,000	4 098 000	97,556,000
West Germany	1 898 600	43,802,000	2 123 000	51,068,000
United Kingdom	1 955 800	30,501,000	2 216 000	50,595,000
Netherlands	184 500	6,984,000	611 000	17,152,000
United States	1 175 700	30,956,000	742 000	12,101,000
France	584 000	13,681,000	376 000	8,585,000
Australia	111 200	2,650,000	194 000	5,323,000
Other countries	384 900	11,570,000	192 000	3,746,000
Total	11 481 900	250,917,000	14 585 000	359,594,000
Imports				
Molybdic oxide (containing less than 1 per cent impurities)	335 900	7,535,000	361 700	5,128,000
Molybdenum in ores and concentrates[3] (Mo content)	271 962	4,798,000	142 317	2,593,000
Ferromolybdenum, over 50% molybdenum[3]	153 945	1,400,000	53 618	867,000
Consumption (Mo content)				
Addition agents	779 594	..	760 168	..
Electrical and electronics	4 266	..	1 751	..
Other Uses[4]	466 084	..	292 893	..
Total	1 249 944	..	1 054 812	..

Sources: Energy, Mines and Resources Canada; Statistics Canada, except where noted.
[1] Producers' shipments (Mo content) of molybdenum concentrates, molybdic oxide and ferromolybdenum. [2] Includes molybdenite, molybdic oxide in ores and concentrates. [3] United States exports of molybdenum to Canada, reported by the U.S. Bureau of Commerce, Exports of Domestic and Foreign Merchandise (Report 410), value in U.S. currency. These imports are not available separately in official Canadian trade statistics. [4] Alloy and pigment uses.
P Preliminary; .. Not available.

Lornex Mining Corporation Ltd. is expanding its mining and milling complex at Highland Valley, British Columbia. The company is adding a third semi-autogenous mill line, along with a new crusher. The new mill line will increase mill capacity by about 68 per cent to a range of between 67 000 and 72 000 tpd of ore. The project, costing approximately $160 million, is scheduled for completion in mid-1981. Along with the expansion, Lornex is installing a molybdenum leaching plant which uses a process that is under license from Brenda Mines Ltd. The Brenda leaching process is capable of removing copper impurities in the molybdenum concentrate from the current 0.9 per cent down to 0.1 per cent to produce a high quality product.

Also in British Columbia, Noranda Mines Limited is spending $12-15 million to expand production capacity at its Boss Mountain molybdenum mine. Mill capacity will be increased to 2 700 tpd from its present level of 1 600 tpd and a new open-pit will be added by the end of 1981.

A molybdenum recovery plant was completed in 1980 at the Granisle mine, acquired by Noranda late in 1979 from Zapata Corporation of Houston, Texas. Noranda plans to bring the plant into operation in 1981 when mill-feed will be derived from the copper-molybdenum zone.

Production at the Brenda copper-molybdenum mine, Canada's second-largest molybdenum producer after Endako, declined in 1980 due partly to lower-grade ore and partly to equipment failure. The company treated an increasing amount of stockpiled ore which had become oxidized and was difficult to treat. In addition, the mill was shut down for repair during July as a result of a broken main shaft in the primary crusher.

Gibraltar Mines Limited, near Williams Lake, British Columbia moved its mining activity from the Pollyana pit to the Stage II of Gibraltar East pit in 1980. All ore production in the second half of the year was derived from the East pit where the company has installed a crusher and conveyor system.

Two mines are being brought into production in British Columbia and one in New Brunswick. In British Columbia, construction at the Highmont copper-molybdenum mine is essentially completed. However, due to some delivery problems with mill equipment, production has been delayed until January, 1981. Initial production at Highmont will be at an annual rate of 2 087 t of molybdenum in sulphide concentrate, but this will decline in subsequent years.

Amax of Canada Limited is developing the Kitsault mine, a former producer located near Alice Arm, British Columbia. Formerly operated by British Columbia Molybdenum Limited, the mine was forced to close in April 1972, after almost 5 years of operation because of poor market conditions, and the property was later sold to Amax. The original mill, designed to process 5 443 tpd of ore, is being expanded to 10 886 tpd. Start-up of production is scheduled for mid-1981.

In New Brunswick, Brunswick Tin Mines Limited, a subsidiary of Sullivan Mining Group Ltd. and Billiton Canada Ltd., began pre-production development in 1980 at the Mount Pleasant mine. The new project is scheduled to begin operation in the second half of 1982. While primarily a tungsten deposit, Mount Pleasant will also produce about 540 tpy of molybdenum contained in concentrate.

Two promising molybdenum prospects were drilled and evaluated in British Columbia. Newmont Exploration of Canada Limited and Esso Minerals Canada continued

TABLE 2. CANADA, MOLYBDENUM PRODUCTION, TRADE AND CONSUMPTION, 1970 AND 1975-80

			Imports		
	Production[1]	Exports[2]	Molybdic oxide[3]	Ferro-molybdenum[4]	Consumption[5]
			(kilograms)		
1970	15 318 593	13 763 800	33 500	29 619	1 036 940
1975	13 323 144	15 710 300	56 400	269 281	1 436 883
1976	14 618 607	14 680 600	110 600	128 845	1 260 329
1977	16 567 555	15 326 100[r]	192 100	74 330	1 149 736
1978	13 943 405	13 421 000	329 500	55 294	1 268 640
1979	11 174 586	11 481 900	335 900	153 945	1 249 944
1980P	12 198 000	14 585 000	361 700	53 618	1 054 812

Sources: Energy, Mines and Resources Canada; Statistics Canada; except where noted.
[1] Producers' shipments (Mo content) molybdenum concentrates, oxide and ferromolybdenum.
[2] Mo content, ores and concentrates. [3] Gross weight. [4] U.S. exports to Canada, reported by the U.S. Bureau of Commerce, Exports of Domestic and Foreign Merchandise (Report 410), over 50 per cent molybdenum. [5] Mo content of molybdenum products reported by consumers.
P Preliminary; [r] Revised.

TABLE 3. CANADA, MINE PRODUCTION, 1980

Company and Mine Name	Location	Type of Producer	Mill Capacity	Ore Milled		Concentrates Produced			Year-end Stocks
				Tonnes	Grade	Tonnes	Grade	Contained Mo	
			(tpd)		(% Mo)		(% Mo)	(tonnes)	(tonnes Mo contained in concentrates)
Placer Development Limited, Endako Mine	Endako, B.C.	Primary	32 500	11 102 997	0.085	13 732	53.40	7 333	3 233
Noranda Mines Limited, Boss Mountain Division	Williams Lake, B.C.	Primary	1 800	483 760	0.170	1 329	57.10	759	137e
Brenda Mines Ltd.	Peachland, B.C.	Coproduct	27 200	9 126 857	0.033	3 834	55.75	2 137	1 451
Lornex Mining Corporation Ltd., Lornex Mine	Highland Valley, B.C.	Byproduct	43 600	16 037 591	0.017	4 110	53.99	2 219	126
Utah Mines Ltd., Island Copper Mine	Port Hardy, B.C.	Byproduct	37 200	13 757 175	0.016	3 056	39.37	1 203	300e
Gibraltar Mines Limited	McLeese Lake, B.C.	Byproduct	36 300	12 643 870	0.012	1 454	53.66	780	29
Bethlehem Copper Corporation, Iona Mine	Highland Valley, B.C.	Byproduct	17 700	6 281 347	0.005	435	49.73	216	30e
Gaspé Copper Mines, Limited, Needle Mountain and Copper Mountain	Holland Twp., Gaspé, Que.	Byproduct	32 800	10 226 322	0.021	1 776	45.33	805	230e
Total								15 452	

Sources: Energy, Mines and Resources Canada; Company annual reports.
e Estimated; tpd tonnes of ore per day.

their underground drilling and sampling program in 1980 at the Trout Lake molybdenum property, south of Revelstoke. Also, Placer continued its diamond drilling program and engineering studies on the Ruby Creek molybdenum property near Atlin. This property was optioned from Adanac Mining and Exploration Ltd. in 1978. Mineable ore reserves of 201 million t grading 0.059 per cent molybdenum have been delineated. Under the terms of option, Placer has the right to earn a 70 per cent interest in this property.

Canadian exports of molybdenum products in 1980 increased by 27 per cent to 14 585 t while export value was up by more than 43 per cent to $359.6 million. On the other hand, imports in all forms decreased by about 18 per cent to 254 550 kg. Consumption during the year was estimated at 1 055 t, 16 per cent lower than 1979.

In July 1980, the Canadian government authorized the start of construction on the Alaska Highway natural gas pipeline's prebuilt section, which comprises 848 km of pipeline in two branches from Calgary to the United States border. Construction of the western and eastern legs of the prebuilt section, which are to be completed in 1981 and 1982 respectively, will require a substantial amount of molybdenum. This one time requirement will result in a substantial increase of domestic consumption.

Major molybdenum consumers in Canada include Atlas Steels Company Limited, Stelco Inc., The Algoma Steel Corporation, Limited, Ford Motor Company of Canada, Limited, Dominion Colour Corporation Limited, Abex Industries Ltd. and Colt Industries (Canada) Ltd. Together these companies account for well over three-quarters of Canadian consumption, much of it in the form of technical-grade molybdic oxide. Most of the remainder is consumed by a large number of iron foundries which require molybdenum, principally in the form of ferromolybdenum.

Ferromolybdenum is made in Canada by Masterloy Products Limited of Ottawa which can produce a variety of ferroalloys using the thermite process. Total ferroalloy production capacity is approximately 1.8 million kg per year, though in recent years the plant has been operating at about 50 per cent of capacity. Masterloy produces ferromolybdenum on a toll-conversion basis and over the past three years has converted between 100 000 and 180 000 kg of molybdenum per year.

WORLD PRODUCTION, CONSUMPTION AND DEVELOPMENT

Western world molybdenum production in 1980 increased by 6 per cent to about 98 000 t compared with 1979. The production increase in Canada was a prime factor. Mine output in the United States increased marginally; an increase in production at the primary molybdenum mines was offset by the lengthy strike at the copper mines which lowered byproduct molybdenum output. Elsewhere in the world, including Chile, molybdenum output increased marginally.

World consumption of molybdenum in 1980 was estimated at 73 000 t, a decline of over 12 per cent from 1979. Demand was lower in both the United States and Europe. On the other hand, despite the economic downturn, molybdenum consumption in Japan was higher in 1980 compared with 1979. The accelerated production of oil well pipes, casing and linepipe resulted in a strong demand for molybdenum.

TABLE 4. WORLD PRODUCTION OF MOLYBDENUM IN ORES AND CONCENTRATES, 1978-80

Country[1]	1978	1979P	1980e
	(tonnes Mo content)		
United States	59 803	65 302	68 350
Chile	13 195	13 559	13 341
Canada	14 347	10 029	15 452
U.S.S.R.e	9 900	10 200	10 400
People's Republic of Chinae	2 000	2 000	2 000
Peru	729	1 182	998
Republic of Korea	220	189	264
Bulgariae	150	150	150
Japan	123	117	118
Philippines	55	124	141
Mexico	11	48	59
Total	100 533	102 900	111 273

Sources: Energy, Mines and Resources Canada; U.S. Bureau of Mines, Minerals Yearbook, Preprint, 1980.

[1] In addition to the countries listed, North Korea, Romania, Turkey and Yugoslavia are believed to produce molybdenum, but output is not reported quantitatively.

P Preliminary; e Estimated.

TABLE 5. PRINCIPAL MOLYBDENUM PRODUCERS IN THE WESTERN WORLD, 1980

Company	Country	Per cent of production
AMAX Inc.	United States	47
Corporacion Nacional del Cobre de Chile (CODELCO)	Chile	14
Duval Corporation	United States	11
Placer Development Limited	Canada	8
Noranda Mines Limited	Canada	4
Kennecott Copper Corporation	United States	4
Molycorp, Inc.	United States	1
Others		11
		100

Six of the 50 primary or byproduct molybdenum mines operating in the world accounted for about 70 per cent of mine output. These are: in the United States, the Climax and Henderson mines of AMAX Inc., Sierrita mine of Duval Corporation, and Utah Copper mine of Kennecott Corporation; in Canada, Placer's Endako mine; and in Chile, Corporacion Nacional del Cobre de Chile's (CODELCO) mine.

AMAX's Climax mine in Golden, Colorado is the world's leading producer. In 1980, it produced over 23 600 t of molybdenum while AMAX's new Henderson mine produced about 22 700 t of contained molybdenum. Henderson mine reached its design capacity output in early 1980. In 1981, AMAX plans to produce a total of 50 000 to 52 000 t of molybdenum in concentrate, including output from the Kitsault mine in British Columbia.

AMAX has two other molybdenum prospects due to come on-stream. These include Mount Tolman mine in Washington and Mount Emmons mine in Colorado. The Mount Tolman property, a co-operative venture between AMAX and the Colville Indian Tribes, will probably produce between 8 000 and 9 000 tpy of molybdenum by 1983 or 1984. The ore at Mount Tolman is close enough to the surface for open-pit mining. At year-end 1980, the company reported ore reserves of 816 million t grading 0.10 per cent molybdenite (MoS_2) and 0.09 per cent copper.

The Mount Emmons property, located near Crested Butte, Colorado, has an indicated ore reserve of 140 million t grading 0.44 per cent molybdenite. Feasibility studies have indicated that the deposit would have to be mined by underground methods at an annual production rate in the range of 10 000 t to 13 600 t of molybdenum. However, Mount Emmons is located in an environmentally sensitive area and development is conditional on obtaining the necessary environmental permits.

Molycorp, Inc., the wholly-owned subsidiary of Union Oil Company of California, continued to produce molybdenum ore from its Questa open-pit mine. Production has been scaled down substantially since the landslide in September 1977 and 1980 output of contained molybdenum was only about 1 800 t. The bulk of the 1980 output was derived from previously stockpiled low-grade material. Molycorp plans to keep the pit in operation until the new Questa underground mine begins production in late 1983 or in early 1984. The new mine, when in full production, will produce about 8 000 to 9 000 tpy of molybdenum in concentrate. Molycorp has also begun construction on a new molybdenum roaster at the site of its present plant in Washington, Pennsylvania, which will begin operation in early 1982. The new roaster will treat molybdenum concentrates from the Questa underground mine and the existing plant will be maintained on a standby basis.

United States Borax & Chemical Corporation, a subsidiary of the Rio Tinto Group, has announced plans to bring the Quartz Hill molybdenum mine near Ketchikan, Alaska into production. This decision came after passage of the Alaska Land Bill by the United States Congress in December, which makes provision for the mining of mineral deposits of critical and strategic importance in a national park area. The Quartz Hill mine, having ore reserves of 1.36 billion t, is expected to produce 54 000 tpd of ore and about 18 000 tpy of molybdenum. The company plans to spend $US 870 million to bring the mine into production by 1987.

Two other new sizable mines coming on-stream in the United States include the Thompson Creek mine in Idaho and the Tonopah (Hall) mine in Nevada. Cyprus Mines Corporation, acquired by Standard Oil Company (Indiana) in 1979, commenced construction at year-end at its Thompson Creek molybdenum mine in Custer County, Idaho. The Thompson Creek orebody, with an ore reserve of at least 180 million t grading 0.18 per cent molybdenite, is mineable by open-pit methods. Commercial production is to begin in the second half of 1983. At capacity, the new mine is expected to produce about 8 000 tpy of molybdenite.

Construction work began early in 1980 at the Tonopah open-pit. Atlantic Richfield Company's wholly-owned subsidiary, The Anaconda Company, plans to bring the mine into operation in October 1981. Annual production capacity will be in the range of 5 400 t to 6 800 t of molybdenum contained in concentrates. By January 1983, the mine will be equipped with a conversion plant with a roasting capacity of 6 800 tpy of molybdenum concentrate.

In October 1980, Minera Frisco S.A. de C.V. brought the Cumobabi Mine into production, Mexico's first molybdenum mine. The Cumobabi mine, which is located near Cumpas, Sonora, Mexico, is scheduled to achieve capacity production of about 1 800 tpy of molybdenum in concentrate by 1982. The company plans to expand its capacity to 4 500 t annually by 1985. A new roaster plant in Cumpas was also brought into operation in 1980 to convert the concentrate from the new mine into molybdic oxide.

In Chile, CODELCO produced about 13 600 t of molybdenum in 1980 from four state-owned copper-molybdenum mines. Total output changed only slightly from 1979. CODELCO has also achieved a higher molybdenum recovery at one of its mines, the El Teniente mine. The recovery improvement was effected by employing a new flotation reagent which raised the overall recovery from 47 per cent to 57 per cent.

PRICES

During the first seven months of 1980, merchant-market molybdic oxide prices weakened as increasing supplies came onto the market. Dealer oxide prices declined from $US 31.42-33.5 per kg at the beginning of January to $US 15.43 per kg at the end of July, a dramatic decline compared with the record high of $71.65 in June 1979. Noranda and Placer, Canada's major molybdenum producers, reduced prices on July 1, 1980 from $US 25.51 per kg to $US 24.25 for technical-grade molybdic oxide, and again to $US 22.27 on October 1, 1980 following a steady falloff in demand on major world markets.

In the United States, despite the decline in demand, the domestic price for technical grade oxide was raised from $19.84 per kg to $21.38 per kg, while the export price was lowered from $24.34 to $22.49 per kg. The price change was effected in part to reduce the large differential between the domestic and export prices.

Prices in U.S. currency, per kilogram of contained molybdenum, fob shipping point, December 31.

	1979	1980
	($US)	
Molybdenum concentrates[1] 95% MoS_2	19.49	20.28
Molybdic oxide[1] (MoO_3) in cans	21.03	22.49
Ferromolybdenum, minimum 60% Mo		
Climax[1]	23.94	25.40
Dealer export[2] (fas port)	36.38- 39.13	17.64- 19.84

[1] Climax quotes; [2] **Metals Week** quote.
fob Free on board, fas Free alongside ship.

OUTLOOK

The outlook for molybdenum over the next few years is for softer markets and excess production capacity as new mines come on-stream. The increase in production will more than offset the fast growing demand for molybdenum for pipelines, solar equipment and other energy related applications. Recent developments on dual phase steel with special applications in the auto industry could, in the future, help alleviate the oversupply situation. Molybdenum is added in dual-phase steel to increase strength and ductility. These properties will permit the automobile manufacturers to reduce the thickness and weight of many components previously produced from carbon and High Strength Low Alloy (HSLA) steel.

New production in the 1980s should contribute to confidence in long-term supply availability. At the same time, the oversupply situation will exert a downward pressure on molybdenum prices and, together, these factors will have a tendency to stimulate demand. The long-term demand will increase but this is likely to be at a lower growth rate than in the past. In certain applications where substitution has taken place because of recent high prices, users are expected to revert back to molybdenum.

TARIFFS

CANADA:

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
32900-1	Molybdenum ores and concentrates	free	free	free	free
33505-1	Molybdenum oxides	10%	14.7%	25%	9.5%
37506-1	Ferromolybdenum	free	5%	5%	free
35120-1	Molybdenum metal in powder, pellets, scrap, ingots, sheets, strips, plates, bars, rods, tubing or wire, for use in Canadian manufactures	free	free	25%	free
92847-1	Molybdates	10%	14.3%	25%	9%
	Temporary reduction, June 3, 1980 to June 30, 1982	free			free
92856-1	Molybdenum carbides	10%	13.1%	25%	8.5%
	Temporary reduction, June 3, 1980 to December 31, 1986	free			free

MFN Reductions under GATT (effective January 1 of year given)

	1980	1981	1982	1983	1984	1985	1986	1987
				(%)				
33505-1	14.7	14.4	14.1	13.8	13.4	13.1	12.8	12.5
37506-1	5.0	5.0	4.8	4.7	4.5	4.3	4.2	4.0
92847-1	14.3	13.6	12.8	12.1	11.4	10.7	9.9	9.2
92856-1	13.1	11.3	9.4	7.5	5.6	3.8	1.9	free

UNITED STATES (MFN)

Item No.									
601.33	Molybdenum ore (per lb on Mo content)	11.6¢	11.3¢	10.9¢	10.5¢	10.1¢	9.8¢	9.4¢	9.0¢
419.60	Molybdenum compounds	4.0%	3.9%	3.8%	3.7%	3.5%	3.4%	3.3%	3.2%
606.31	Ferromolybdenum	10¢/ lb on Mo content + 3%	10¢/ lb on Mo content + 3%	6.3%	5.9%	5.6%	5.2%	4.9%	4.5%
628.70	Molybdenum metal, waste and scrap (suspended to June 30, 1981)	9.9%	9.4%	8.8%	8.3%	7.7%	7.1%	6.6%	6.0%

TARIFFS (cont'd)

UNITED STATES (MFN) (cont'd)

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
628.72	Molybdenum metal, unwrought	9.5¢/ lb on Mo content +2.9%	9¢/ lb on Mo content +2.7%	8.6¢/ lb on Mo content +2.6%	8.1¢/ lb on Mo content +2.5%	7.6¢/ lb on Mo content +2.3%	7.2¢/ lb on Mo content +2.2%	6.7¢/ lb on Mo content +2.0%	6.3¢/ lb on Mo content +1.9%
628.74	Molybdenum metal, wrought	11.8%	11.0%	10.3%	9.6%	8.8%	8.1%	7.3%	6.6%
417.28	Ammonium molybdate	6.0%	5.7%	5.5%	5.3%	5.0%	4.8%	4.5%	4.3%
418.26	Calcium molybdate	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%	4.7%	4.7%
421.10	Sodium molybdate	4.9%	4.8%	4.6%	4.4%	4.2%	4.1%	3.9%	3.7%
423.88	Molybdenum carbide	3.5%	3.4%	3.3%	3.2%	3.1%	3.0%	2.9%	2.8%

EUROPEAN ECONOMIC COMMUNITY (MFN)

Item No.		1980	Base Rate	Concession Rate
26.01	Molybdenum ores and conc.	free		
28.28	Molybdenum oxides and hydroxides	7.7%	8.0%	5.3%
73.02	Ferromolybdenum	7.0%	7.0%	4.9%
81.02	Molybdenum metal			
	A. Unwrought powder	6%		
	other	5%		
	B. Wrought: bars, angles, plates, sheets, strip, wire	8%		
	C. Other	10%		
28.47	Molybdates	7.8%	11.2%	6.6%
28.56	Molybdenum carbides	8.6%	9.6%	8.0%

JAPAN (MFN)

Item No.				
26.01	Molybdenum ores and conc.			
	A. Quota	free		
	B. Other	5.6%	7.5%	free
28.28	Molybdenum trioxide	3.9%	5.0%	3.7%
73.02	Ferromolybdenum	5.7%	7.5%	4.9%
81.02	Molybdenum metal			
	A. Unwrought, powders and flakes	3.9%	5.0%	3.7%
	B. Waste and scrap	3.9%	5.0%	3.7%
	C. Other	5.7%	7.5%	4.9%
28.47	Molybdates	5.7%	7.5%	4.9%
28.56	Molybdenum carbides	3.9%	5.0%	3.7%

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated 1980, USITC publication 1011; U.S. Federal Register, Vol. 44, No. 241; Official Journal of the European Communities, Vol. 22, No. L342, 1979; Customs Tariff Schedules of Japan, 1980.

Nepheline Syenite and Feldspar

B.W. BOYD

Nepheline syenite is a white to whitish-grey, medium-grained igneous rock resembling granite in texture. It consists of nepheline, potash and soda feldspar, and accessory mafic minerals such as biotite, hornblende and magnetite. Although nepheline syenite is a rock type known to occur in many parts of Canada, its development for industrial application is limited to those deposits from which iron-bearing accessory minerals can readily be removed; its major uses are in the glass and ceramics industries.

The use of nepheline syenite as a raw material for glass, ceramic and the filler industries was first developed in Canada, the world's sole producer for many years. Canada's only competitor in the field, Norway, began nepheline syenite mining in 1971. Although the U.S.S.R. began mining nepheline syenite on the Kola Peninsula during the 1930s, the deposit was worked for its phosphate content. Byproduct nepheline from the Kola deposit became an important source of aluminum and is still being used for this purpose. Nepheline syenite is also quarried in the United States for use as aggregate, railway ballast, jettystone and roofing granules.

Canada's nepheline syenite industry began in 1932 with the staking of five claims on Blue Mountain, 40 kilometres (km) northeast of Peterborough. A long period of persistent efforts in technical and market research and in development was necessary before this unique industry became established. Today there are two mills in operation on Blue Mountain, processing rock from several quarries.

Over the years nepheline syenite has become preferred to feldspar as a source of alumina and alkalis for glass manufacture. Its use results in more rapid melting of the batch at lower temperatures than with feldspar, thus reducing fuel consumption, lengthening the life of furnace refractories and improving the yield and quality of glass. Other industrial uses for nepheline syenite include ceramic glazes, enamels, and fillers in paints, papers, plastics and foam rubber.

Feldspar is the name of a group of minerals consisting of aluminum silicates of potassium, sodium and calcium. Feldspar is used in glassmaking as a source of alumina and alkalis, in ceramic bodies and glazes, in cleaning compounds as a moderate abrasive and as a flux coating on welding rods. High calcium feldspars, such as labradorite, and feldspar-rich rocks, such as anorthosite, find limited use as building stones and for other decorative purposes. Potash feldspar is an essential ingredient in the manufacture of high voltage porcelain insulators. Dental spar, which is used in the manufacture of artificial teeth, is a pure white potash feldspar, free of iron and mica.

Feldspar occurs in many rock types, but commercially viable deposits are mostly restricted to coarse-grained pegmatites from which the mineral is concentrated by flotation or, less commonly, by handcobbing. It is then ground to the desired size. Nearly all of the feldspar produced in Canada has come from pegmatites in the Precambrian rocks of southern Ontario and southwestern Quebec.

TABLE 1. CANADA, NEPHELINE SYENITE PRODUCTION, EXPORTS, 1979 AND 1980 AND CONSUMPTION, 1978 AND 1979

	1979		1980	
	(tonnes)	($)	(tonnes)	($)
Production (shipments)	605 699	15,180,042	599 699	15,935,661
Exports				
United States	440 526	12,026,000	406 283	12,255,000
Italy	11 538	276,000	15 601	550,000
Netherlands	2 328	50,000	9 181	253,000
Australia	1 283	62,000	8 954	337,000
United Kingdom	11 205	248,000	3 758	170,000
France	689	48,000	1 341	95,000
Japan	562	39,000	908	58,000
Other countries	2 924	138,000	2 440	139,000
Total	471 055	12,887,000	448 466	13,857,000

	1978	1979
	(tonnes)	
Consumption[1] (available data)		
Glass and glass fibre	47 836	52 362
Ceramic products	18 691	16 379
Insulation	13 590	11 541
Paints	7 669	4 240
Rubber products	679	748
Others[2]	329	1 517
Total	88 794	86 787

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Total and breakdown by Energy, Mines and Resources Canada. [2] Includes frits and enamel, foundry, plastics, electrical apparatus and other minor uses.

CANADIAN PRODUCTION AND DEVELOPMENTS

Nepheline syenite production comes from two operations on Blue Mountain in Methuen Township, Peterborough County, Ontario. The deposit is pearshaped, approximately 8 km long, and up to 2.4 km wide. The iron content of the rock is distributed quite uniformly, but selective quarrying, blending of quarry material, and careful pit development are necessary to ensure a mill product capable of meeting consumer specifications. In general, the nepheline syenite zone is underlain by syenites and overlain by steeply dipping biotite schists. Nepheline syenite reserves are sufficient to satisfy demand for the foreseeable future.

Indusmin Limited, a subsidiary of Falconbridge Nickel Mines Limited, is the larger producer. It maintained its shipments at the record level of about 390 000 tonnes (t), established a year earlier, for a value of nearly $12 million in 1980. Ore is loaded by front-end loaders into trucks for haulage to the mill at Nephton. Several grades of nepheline syenite are produced; they are based on combinations of different mesh sizes and iron contents. Iron-bearing minerals are almost totally removed by electromagnetic methods. The mill operates three shifts a day, seven days a week. Expansion of the tertiary crushing and magnetic separation circuits increased capacity to about 410 000 t of product annually. Seventy-five to eighty per cent of the material mined is recovered as product in the mill with the result that there is very little waste to dispose of. Finished products are transported by rail to domestic and export markets. The United States accounts for over 65 per cent of Indusmin's sales.

IMC Chemical Group (Canada) Ltd. a wholly-owned subsidiary of International Minerals & Chemical Corporation, operates quarries and a plant about 6 km east of Indusmin's operation; the mill was constructed in 1956. Present capacity is 1 000 tpd and shipments in 1980 were well over 200 000 t. The mill operates three shifts daily, five days a week, and produces a variety of products. Rock is mined from an open pit adjacent to the mill and a certain degree of blending is required to ensure an acceptable mill feed. A major expansion was initiated in 1980 and should be completed in 1981. Ore reserves are sufficient for many years.

Some 65 per cent of IMC's production is exported to the United States. The company produces three grades of nepheline syenite for glass, enamel, glass fibre and other applications, but the product line will be extended with the changes in the mill associated with the expansion.

An increase in average price was noted in 1980. Recognition by glassmakers of the superior properties, consistent quality, long-term reliable supply and low cost of nepheline syenite, compared with feldspar, led to substantial growth in production in the 1950s and 1960s. During the first half of the last decade growth was stagnant because of several factors, including strikes in the consuming industries, shortages of rail cars and, finally, stable demand. From 1975 to 1979 demand grew by about 7 per cent annually and production increases kept pace.

As a result of substitution of nepheline syenite, output of feldspar declined steadily from 55 000 t in 1947 to 5 000 t in recent years. This competition led to the closure of Canada's last major feldspar operation, (International Minerals & Chemical Corporation (Canada) Limited in Buckingham, Quebec) in 1972. Several local producers of high-value dental spar had delivered small tonnages to the mill at Buckingham until the closure. In 1974, one operation shipped several tonnes to Sweden and an enquiry for several hundred tonnes was received during 1975 from a North American manufacturer. Early in 1979, Johnson & Johnson Limited of Montreal undertook evaluation of dental spar deposits in the area. Since then, shipments of dental spar amounting to a few hundred tonnes a year have been sent to the United States by small independent operators.

Tantalum Mining Corporation of Canada Limited mines tantalum and lithium at Bernic Lake, Manitoba from a pegmatite containing abundant feldspar. This company could recover a clean quartz-feldspar product, should market demand warrant.

OTHER DOMESTIC OCCURRENCES

Nepheline syenite is known to occur in many localities in Canada but, to date, only the Blue Mountain deposit has proven amenable to economic mining and milling to produce material suitable for the glass and ceramic markets.

An extensive body of nepheline syenite which outcrops in the Bancroft area of Ontario was tested in the late 1930s but variability of nepheline content and high iron contents made the product unacceptable. Coldstream Mines Limited discontinued exploration work in 1971 on a large nepheline syenite intrusive near Port Coldwell, Ontario, after obtaining discouraging results from petrologic and metallurgical studies.

Nepheline syenite occurs in several localities in southern British Columbia, notably in the Ice River area, near Field, and in the Big Bend area on the Columbia River.

Nepheline is a common mineral constituent in the alkaline complexes of northern Ontario and southern Quebec, but none of these deposits is, as yet, of economic significance.

Feldspar is the major mineral constituent of pegmatite dykes, which are widely distributed in Canada. Any large deposit near potential markets warrants investigation. Feldspar accompanied by byproduct silica can also be produced from granitic rocks of suitable composition by flotation.

MARKETS

In 1980, 75 per cent of Canada's nepheline syenite output was exported. Sales to the United States fell by 8 per cent but still accounted for over 90 per cent of exports. Offshore sales increased by 38 per cent due mainly to increased exports to Italy, Netherlands and Australia.

TABLE 2. CANADA, NEPHELINE SYENITE PRODUCTION AND EXPORTS, 1970, 1975-80

	Production[1]	Exports
	(tonnes)	
1970	454 110	351 940
1975	468 427	356 629
1976	540 121	418 975
1977	574 558	443 763
1978	599 121	420 962
1979	605 699	471 055
1980	599 699	448 466

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Producers' shipments.

Domestic shipments increased marginally to 151 000 t.

In the glass industry, 15 to 20 per cent by weight of the glass batch is nepheline syenite. Material with a size range of minus 30 mesh to plus 200 mesh and with an iron content of less than 0.1 per cent is required in the production of flintglass. An iron content as high as 0.6 per cent, expressed as Fe_2O_3, is allowable for the manufacture of coloured glass. A typical chemical analysis for high-quality nepheline syenite produced in Canada for glass manufacture is:

Silica SiO_2 - 60.00
Alumina Al_2O_3 - 23.60
Iron Fe_2O_3 - 0.07
Lime CaO - 0.30
Magnesia MgO - 0.10
Potash K_2O - 5.30
Soda Na_2O - 10.20
Loss-on-ignition - 0.50

A growing market is developing for finely ground material in the whiteware industry. The finer grades used for ceramic applications are produced by reducing the basic minus 30 mesh material in pebble mills. In ceramics, nepheline syenite is used as both a body and a glaze ingredient. High-purity material in the minus 200 to plus 325 mesh size and with an iron content of 0.07 per cent Fe_2O_3, or less, is most frequently used. Products utilizing this material include bathroom fixtures, vitreous enamels for appliances, china, ovenware, electrical porcelain and ceramic artwares.

Very finely ground material is being used increasingly as a filler in plastics, foam rubber and paints. The very fine grain size, high reflectance and low oil absorption are important physical characteristics which make nepheline syenite an excellent filler material in the above products, and in vinyl, floor and wall tile.

A low-grade nepheline syenite is sold in bulk for use in the manufacture of fibre glass and for glazing on brick and tile. Some material with high iron content is used in the manufacture of mineral wool, and as an aggregate.

TABLE 3. CANADA, ESTIMATED FELDSPAR CONSUMPTION, 1978 AND 1979

	1978	1979
	(tonnes)	
Consumption		
Whiteware	4 485	4 317
Other products[1]	101	89
Total	4 586	4 406

Source: Energy, Mines and Resources Canada.

[1] Includes porcelain enamel, artificial abrasives and other minor uses.

In ceramics, potash feldspar is used to bind the ceramic mix into what the industry terms a "body", and it is essential in the manufacture of electric porcelain for high voltage purpose. Substitution of alternative materials for feldspar in ceramic manufacture has been less severe than in the manufacture of glass. The principal reason is that raw material costs are low in the ceramic industry in relation to total manufacturing costs, and manufacturers adopt a new raw material only after cautious trial use. Further, while the higher alumina content of nepheline syenite has been a decisive factor in the replacement of feldspar in glass manufacture, a high alumina content is less critical in ceramic manufacture. The domestic market for feldspar appears to be firm at around 4 000 to 5 000 tpy.

WORLD REVIEW

The Norsk Nefelin Division of Elkem Spigerverket is western Europe's only producer of nepheline syenite. Operations at the plant, near Hammerfest in northern Norway, began in 1961 and production increased steadily. An expansion, completed in 1973, raised capacity from 175 000 to 225 000 tpy. Production levelled off at 220 000 t in 1980. The lenticular deposit is about 2 km long and at least 250 metres (m) deep. Unlike Canadian producers, Norsk Nefelin uses underground mining methods. Nepheline syenite is supplied to the glass, ceramic and enamel industries in two main grades. The finer-mesh, ceramic-grade material is usually shipped in bags, whereas the coarser glass-grade is shipped in bulk to European markets. The company employs a modern fleet of "coasters" on long-term charter and ships finished products to storage and distribution centres in major market areas.

TABLE 4. CANADA, IMPORTS AND CONSUMPTION OF CRUDE OR GROUND FELDSPAR, 1975-79

	Imports ($)	Consumption (tonnes)
1975	..	5 630
1976	106,000	4 053
1977	275,000	4 271
1978	762,000	4 586
1979	501,000	4 406
1980	385,000	..

Sources: Statistics Canada; Energy, Mines and Resources Canada.

.. Not available.

Nepheline syenite is an important source of alumina for aluminum production in the U.S.S.R. Very large deposits occur near Kirovsk in the Kola Peninsula and also in the Lake Baikal region of Siberia. At the Kola deposits byproduct nepheline that contains 30 per cent Al_2O_3 is recovered by a process in which limestone is added to the nepheline concentrates and the mix is sintered and treated with caustic soda to yield anhydrous alumina, soda, potash and cement. Elsewhere in the world, rising bauxite prices and concern about raw material supply have stimulated research into alternative domestic sources of alumina, such as nepheline and anorthosite.

Feldspar still retains a major share of its traditional markets outside North America, although Norwegian nepheline syenite has been making headway in these markets. World production of feldspar in 1980 decreased slightly.

TABLE 5. WORLD PRODUCTION OF FELDSPAR, 1979 AND 1980

	1979	1980^e
	(tonnes)	
United States	671 000	653 000
West Germany	390 000	381 000
Italy	250 000	240 000
France	190 000	181 000
Mexico	127 000	118 000
Brazil	117 000	109 000
Spain	90 000	86 000
Other countries	1 258 000	1 225 000
Total	3 093 000	2 993 000

Source: U.S. Bureau of Mines, Mineral Commodity Summaries, 1981.
^{e} Estimated.

OUTLOOK

The outlook for nepheline syenite continues to improve. Canadian shipments offshore, mainly to Europe have, in the last two years, exceeded pre-1970 levels. This is believed to be because of the low capacity at Norsk Nefelin's plant. The scope for increasing Canadian sales to Europe and elsewhere is improving as energy prices rise, thereby increasing the attractiveness of using nepheline syenite in place of feldspar in glass manufacture.

Over the last several years, the market for micronized material used as a filler and extender in plastics, paint, rubber and paper has grown more rapidly than that for use in glassmaking, and further diversification and growth of these markets is expected. Norway does not produce these finely ground grades.

The phenomenal growth rate enjoyed by the nepheline syenite industry during the 1950s and 1960s has moderated as markets formerly supplied by feldspar approached saturation. Since 1970, average growth has been less than 3 per cent.

With increasing requirements for electrical energy, the demand for feldspar, essential in high voltage porcelain, could elevate this raw material to a position of prime importance. Notwithstanding the weakness in the economy, supply for this purpose is likely to remain tight. Rising prices and growing markets could provide an opportunity to develop a suitable Canadian deposit in the near future.

PRICES

The average price for nepheline syenite in Canada was $26.57 fob plant although products range in price from half that value to over $100/t. Prices for glass grade nepheline syenite (30 mesh) were $24 to $27/t and for ceramic grade (200 mesh, bagged) $46 to $52/t in 1980. The largest export market is the United States, where entry is duty free. In the European market the competition is from the Norwegian producer, whose prices were about $100 and $155/t for the glass and ceramic grades, respectively, delivered in Europe.

PRICES OF FELDSPAR IN U.S. CURRENCY

(per short ton, bulk, fob mine or mill, carload lots depending on grade)

	($)
North Carolina	
40 mesh, flotation	41.00
20 mesh, flotation	25.50
200 mesh, flotation	38.25
Georgia	
200 mesh	58.00
40 mesh, granular	41.00
Connecticut	
200 mesh	41.75
20 mesh, granular	30.25

Source: Engineering and Mining Journal, October 1980.
fob - Free on board.

TARIFFS

CANADA

Item No.		British Preferential (%)	Most Favoured Nation (%)	General (%)	General Preferential (%)
29600-1	Feldspar, crude	free	free	free	free
29625-1	Feldspar, ground but not further manufactured	free	7.3	30	free
29640-1	Ground feldspar for use in Canadian manufactures	free	free	30	free

MFN Reductions under GATT (effective January 1 of year given)

	1980	1981	1982	1983	1984	1985	1986	1987
					(%)			
29625-1	7.3	7.0	6.8	6.5	6.3	6.0	5.8	5.5

UNITED STATES

Item No.		
522.31	Crude feldspar	free

TARIFFS (concl'd.)

		1980	1981	1982	1983 (%)	1984	1985	1986	1987
522.41	Feldspar, crushed, ground or pulverized	3.4	3.3	3.2	3.2	3.1	3.0	2.9	2.8

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States, Annotated 1980, USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241.

Nickel

R.G. TELEWIAK

Canada's production of nickel in 1980 was 194 950 tonnes (t) valued at $1,678.6 million compared to 126 482 t valued at $828.6 million in 1979. Production in 1979 had been depressed due to the strike at Inco Limited's Sudbury operations, which lasted from September 16, 1978 to June 3, 1979. Average annual production during the 1970s, excluding the strike affected years of 1978 and 1979, was 251 640 t or about 129 per cent of 1980 production. Canada resumed its position in 1980 as the world's largest producer, and accounted for 25 per cent of total world production, followed by the U.S.S.R. with 20 per cent, New Caledonia with 11 per cent and Australia with 9 per cent.

Consumption was lower in the non-communist world nearly 13 per cent in 1980, and with a reduction in consumer inventories, demand was down by about 15 per cent. Reduced orders in combination with the high carrying cost on inventories were the main factors behind the drawdown of consumer inventories. Producers reacted to the decrease by maintaining their production significantly below capacity, but inventories still increased by 35 000 t to 180 000 t, a level which was still considered to be in the manageable range.

CANADIAN OPERATIONS AND DEVELOPMENTS

Three companies mined nickel ore in Canada during 1980. The largest producer was Inco Limited, which operated mines in Ontario and Manitoba. Falconbridge Nickel Mines Limited, the second-largest producer, treated ores from its mines located in Ontario. Inco and Falconbridge each have integrated mine-concentrator-smelter and refinery complexes where they process ore to the metal stage. The other concentrate producer, Union Minière Explorations and Mining Corporation Limited, operates a copper mine in northwestern Ontario that produces byproduct nickel.

Inco Limited is the world's largest producer of nickel. In 1980 it produced 178 716 t of nickel in finished products, and of this, close to 90 per cent came from ore mined and smelted in Canada. A production cutback was instituted in both Ontario and Manitoba in the second half of the year, in response to reduced nickel demand, but personnel layoffs were not necessary. A manpower attrition policy was started at the Ontario Division in July, and in Manitoba a policy was carried out to fill only a portion of the positions vacated due to resignation and retirement. Also in Manitoba, a portion of the workforce was diverted from production to development work. At Sudbury the Clarabelle open-pit was put on standby near the end of June.

In Ontario, Inco operated ten mines, three concentrators, a smelter, and a nickel refinery in the Sudbury district; a mine and concentrator at Shebandowan, northwestern Ontario; and a nickel refinery and additive plant at Port Colborne. At Thompson, Manitoba, the company operated two mines, a concentrator, a smelter and a refinery. The company also had seven mines on standby

TABLE 1. CANADA, NICKEL PRODUCTION, TRADE AND CONSUMPTION, 1979 AND 1980

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Production[1]				
All forms				
Ontario	88 445	566,279,308	155 665	1,312,139,000
Manitoba	38 037	262,338,084	39 282	366,468,000
Total	126 482	828,617,392	194 947	1,678,607,000
Exports				
Nickel in ores, concentrates and matte[2]				
Norway	26 733	103,628,000	25 094	157,389,000
United Kingdom	16 002	112,143,000	17 553	135,256,000
Japan	-	-	1	6,000
Total	42 735	215,771,000	42 648	292,651,000
Nickel in oxides				
United States	8 413	50,177,000	7 632	59,850,000
EEC	6 101	45,512,000	5 292	48,843,000
Other countries	2 676	16,731,000	4 065	36,086,000
Total	17 190	112,420,000	16 989	144,779,000
Nickel and nickel alloy scrap				
United States	1 497	5,742,000	1 662	5,634,000
West Germany	43	203,000	412	2,768,000
United Kingdom	41	75,000	178	509,000
Belgium-Luxembourg	-	-	17	136,000
Other countries	801	1,475,000	160	277,000
Total	2 382	7,495,000	2 429	9,324,000
Nickel anodes, cathodes, ingots, rods				
United States	56 960	333,205,000	50 318	387,402,000
EEC	17 111	99,110,000	21 048	149,654,000
Other countries	10 634	62,725,000	16 744	122,206,000
Total	84 705	495,040,000	88 110	659,262,000
Nickel and nickel alloy fabricated material, n.e.s.				
United States	9 395	65,087,000	10 317	88,507,000
Finland	1	8,000	4 633	41,148,000
Belgium-Luxembourg	481	2,918,000	1 316	8,493,000
United Kingdom	114	769,000	637	4,748,000
Netherlands	491	3,575,000	461	4,580,000
Japan	405	2,351,000	299	2,316,000
Other countries	963	5,832,000	1 202	9,295,000
Total	11 850	80,540,000	18 865	159,087,000
Imports				
Nickel in ores, concentrates and scrap				
United States	3 252	5,355,000	11 902	36,001,000
Australia	8 368	35,550,000	4 254	19,878,000
South Africa	869	3,467,000	1 453	4,778,000
Belgium-Luxembourg	110	135,000	1 286	2,261,000
Other countries	8,577	4,992,000	7 255	3,750,000
Total	21,176	49,499,000	26 150	66,668,000

TABLE 1. (cont'd.)

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Nickel anodes, cathodes, ingots, rods				
Norway	1 511	9,513,000	1 708	15,370,000
United States	1 774	11,200,000	2 410	4,075,000
U.S.S.R.	-	-	200	1,210,000
Philippines	-	-	19	155,000
Other countries	32	214,000	7	62,000
Total	3 317	20,927,000	4 344	20,872,000
Nickel alloy ingots, blocks, rods and wire bars				
United States	901	3,728,000	829	6,550,000
Belgium and Luxembourg	-	-	30	196,000
West Germany	37	233,000	21	114,000
Other countries	101	663,000	-	-
Total	1 039	4,624,000	880	6,860,000
Nickel and alloy plates, sheet, strip				
United States	2 057	17,188,000	955	12,639,000
West Germany	378	1,984,000	328	2,648,000
United Kingdom	861	7,280,000	107	1,065,000
Other countries	44	90,000	5	72,000
Total	3 340	26,542,000	1 395	16,424,000
Nickel and nickel alloy pipe and tubing				
United States	1 722	22,235,000	591	8,432,000
West Germany	190	4,159,000	173	3,528,000
Sweden	67	890,000	75	1,907,000
Other countries	34	298,000	34	500,000
Total	2 013	27,582,000	873	14,367,000
Nickel and alloy fabricated material, n.e.s.				
United States	838	8,115,000	776	17,505,000
West Germany	40	291,000	47	339,000
United Kingdom	262	535,000	7	125,000
Sweden	3	40,000	5	73,000
Other countries	416	2,432,000	12	124,000
Total	1 559	11,413,000	847	18,166,000
Consumption[3]	8 336	..	..	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Refined nickel and nickel in oxides and salts produced, plus recoverable nickel in matte and concentrates exported. [2] For refining and re-export. [3] Consumption of nickel, all forms (refined metal and in oxides and salts) as reported by consumers.

P Preliminary; - Nil; .. Not available; n.e.s. Not elsewhere specified.

throughout the year. At year-end, Inco had proven and probable ore reserves in Canada of 493 million t containing 7.3 million t of nickel and 4.4 million t of copper.

On September 2, the Ontario government imposed an immediate SO_2 emission control limit of 2 270 tpd on Inco's Sudbury operations. Inco was able to comply with the new regulation as production was already reduced due to weak market conditions, but the new ceiling reduced the company's annual productive capability in Ontario to 127 010 t of nickel from 154 220 t. The regulation also stipulated that effective December 31, 1982, daily emissions shall not exceed 1 770 t, which would restrict capacity to 104 325 t unless improved emission controls were put in place.

In late August, Inco announced that a new pyrrhotite separation facility would be built to reduce emissions by 25 per cent. Phase 1 of the operation includes installation of regrind mills, flotation cells and related equipment in the Copper Cliff mill at a cost of $13 million. Phase 2, which is expected to cost at least twice this amount, will be directed to reducing losses of precious metals and nickel associated with the process. The desired rejection of pyrrhotite, which contains three-quarters of the sulphur in the Sudbury ore, will be achieved in Phase 1, but a cyanide chemical operation is needed to bring the metal losses down to tolerable levels. Construction of Phase 2 was not fully committed because certain process variations associated with the use of cyanide had not been adequately assessed at the pilot plant stage.

Falconbridge Nickel Mines Limited operated six mines, two concentrators and one smelter in the Sudbury area of Ontario. One of these mines, the North, was brought back on-stream in the third quarter of the year and this meant that all the mines which had previously been on standby were now back in production. Development continued at the Fraser mine with production scheduled to begin in late 1981. In January, Falconbridge commenced production from a second electric furnace at its new smelter and this completed an $83 million smelter environmental improvement program initiated in 1974. Employment at year-end increased by 244 over the 1979 level to total 3,886. The company's proven and probable ore reserves at Sudbury were reported to be 71.3 million t containing 1.1 million t of nickel and 0.6 million t of copper. The pace of exploration on the company's properties increased during 1980 and the results included a new high-grade copper zone being discovered at the Strathcona mine, and ore reserves being substantially increased at the Craig deposit. All smelter matte was shipped to the company's refinery in Norway.

The nickel refinery of Sherritt Gordon Mines Limited at Fort Saskatchewan, Alberta operated during the year near its rated capacity and produced a total of 16 235 t of nickel. This was 12 per cent higher than 1979 production. During 1978 the company signed a long-term nickel feed contract with Inco Limited which ensures the continued viable operation of the refinery, using Canadian material. The company has not had a substantial internal source of refinery feed since the closure of its Lynn Lake mine in 1976. During 1980 the major portion of the company's refinery feed came from Inco.

Two orebodies which contain uranium and nickel occur in the Key Lake area of northern Saskatchewan and are being developed by the Key Lake Mining Corporation. Formal hearings by the Key Lake Board of Inquiry to examine the uranium mine and mill proposal were held in mid-1980. Recommendations concerning the conditions under which the development might proceed were scheduled for assessment by the Saskatchewan government in 1981. Commercial production has been scheduled to begin in 1983 but although the orebodies contain close to 2 per cent nickel, current plans are to let the nickel go into tailings, due to contamination problems.

New Quebec Raglan Mines Limited reviewed previous feasibility studies on its Ungava property, conducted an airborne magnetic survey and cleaned up and rehabilitated the existing facilities. The deposits are high-grade but relatively small and widespread. Plans were made for a drilling program in 1981 to endeavour to increase tonnage in one or two central localities.

WORLD DEVELOPMENTS

Major producers in various parts of the world operated well below their capacities for most of the year, and in some locations temporary shutdowns were necessary. Ferro-nickel demand is particularly sensitive to recessionary pressures, and producers of this commodity were hit especially hard by depressed demand and an accentuation of the already unfavourable price-to-operating-costs ratio.

TABLE 2. CANADA, NICKEL PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975-80

		Exports					
	Production[1]	In Matte etc.	In Oxide Sinter	Refined Metal	Total	Imports[2]	Consumption[3]
				(tonnes)			
1970	277 490	88 805	39 821	138 983	267 609	10 728	10 699
1975	242 180	84 391	38 527	91 164	214 082	12 847	11 308
1976	240 825	74 296	47 958	90 329	212 583	16 829	9 972
1977	232 512	80 546	35 005	74 629	190 180	2 406	9 033
1978	128 310	39 077	27 792	105 663	172 532	1 439	11 790
1979	126 482	42 735	17 190	84 705	144 630	3 316	8 336
1980P	194 947	42 648	16 989	88 110	147 747	4 344	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] Refined metal and nickel in oxide and salts produced, plus recoverable nickel in matte and concentrates exported; [2] Refined nickel, comprising anodes, cathodes, ingots, rods and shot; [3] Consumption of nickel, all forms (refined metal, and in oxides and salts), as reported by consumers.
P Preliminary; .. Not available.

Falconbridge Dominicana, C. por A. closed its operations initially for three months starting the end of July, but extended the closure for an additional two months when ferronickel demand failed to rebound. Inventories were reduced sufficiently in late November to permit the company to announce that production would be resumed in early January, 1981.

In Guatemala, Exploraciones y Explotaciones Mineras Izabal, S.A. (Exmibal) operated at approximately 80 per cent of rated capacity for the first nine months of the year, producing 6 940 t of nickel in matte, and then closed its operations in the fourth quarter. The operation is a high-cost producer owing to its reliance on fuel oil-generated electric power. In early November, a further 35 per cent increase in oil prices, along with reduced receipts due to low nickel prices, led Exmibal's parent company, Inco to announce that the operations would remain on standby throughout 1981. In addition to debt servicing charges and depreciation costs, a further $14 million will be spent to maintain the operations on standby. Earlier in the year the Guatemalan government announced that certain tax changes were under consideration, including an export tax on nickel and the elimination of the right to carry forward losses to offset taxable income in future periods. The only tax change enacted by government before its December 15 constitutional deadline, was a change in the stamp tax which would add $1 million to Exmibal's annual operating costs if the facilities were in operation.

Inco's Indonesian subsidiary, P.T. International Nickel Indonesia, operated at about one-half capacity in 1980 with 19 500 t of nickel being produced, compared with the earlier projected 21 320 t. Annual capacity is 36 000 t. In a further effort to solve some of the technical problems associated with the operation from its start up, the furnace linings were fortified with additional cooling devices and modifications were made to the furnace feed.

The expansion of Cuban production was slowed in 1980. Only 25 per cent of construction at the new Punta Gorda plant had been completed and commencement of the first production line was rescheduled from the previously announced start up date of 1982, to the third quarter of 1983. Eventual output from this plant is set at 30 000 t annually and a second plant of the same capacity, Came-1, is planned nearby. Construction was reportedly delayed due to problems with quantity and quality of labour and the internal organization of the plant. Cuba's plans to boost nickel production to close to 100 000 tpy by 1985 were reportedly put back to 1990.

Production in New Caledonia totalled 83 600 t for the year, or less than one per cent higher than the 1979 tonnage. In early December, Société Métallurgique Le Nickel (SLN) announced that one of its three 33 000

TABLE 3. PRODUCING CANADIAN NICKEL MINES, 1980 AND (1979)

Company and Location	Mill or Mine Capacity (tonnes ore/day)		Grade of Ore Nickel (%)	Grade of Ore Copper (%)	Ore Milled (tonnes)	Contained Nickel in Ore Milled (tonnes)	Remarks
Ontario							
Falconbridge Nickel Mines Limited	12 790 (12 790)		.. (..)	.. (..)	2 967 632 (2 500 190)	30 162[1] (25 457)[1]	The North mine reopened in the third quarter.
East, Falconbridge, North, Lockerby, Onaping and Strathcona mines	2 720	(Falconbridge)					
	7 710	(Strathcona)					
Falconbridge	2 360	(Fecunis Lake)					
Inco Limited	69 300 (69 300)		.. ..	.. ..	10 608 827[2] (5 339 227)[2]	166 962[3] (100 753)[3]	Clarabelle was put on standby at end of June.
Clarabelle, Coleman, Copper Cliff South, Creighton, Frood, Garson, Levack, Little Stobie, McCreedy West and Stobie mines	31 800	(Clarabelle)					
	21 800	(Frood-Stobie)					
	5 400	(Levack)					
	10 300	(Creighton)					
Sudbury							
Shebandowan mine Shebandowan	2 720 (2 720)		.. (..)	.. (..)	See above[2] (See above)[2]	See above[3] (See above)[3]	
Union Minière Explorations and Mining Corporation Limited (Umex) Thierry mine	3 600 (3 600)		0.11 (0.11)	1.20 (1.15)	1 080 000 (956 291)	238 (242)	Production was below capacity due to weak copper markets.
Manitoba							
Inco Limited Pipe No. 2 and Thompson Thompson	12 700 (12 700)		.. ..	.. ..	2 557 454 (2 269 680)		

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[1] Total nickel in matte. [2] Includes Shebandowan. [3] Total nickel in ore milled.
..Not available.

TABLE 4. PROSPECTIVE CANADIAN NICKEL MINES

Company and Location	Tonnage and Ore Grade (%)	Year Production Expected	Destination of Nickel Concentrates	Remarks
Quebec				
New Quebec Raglan Mines Limited	14.6 million Ni(2.58) Cu(0.72)	..	..	Extensive review of feasibility studies carried out in 1980.
Renzy Mines Limited, Hainault Township	1.2 million Ni(0.69) Cu(0.72)	..	..	Operations ceased after crushing plant destroyed by fire in 1974.
Ontario				
Falconbridge Nickel Mines Limited, Falconbridge	.. Ni(..)		Falconbridge	
Craig		..		Exploration in 1980 substantially increased reserves.
Fraser mine	Cu(..)	1981		Under development for production in 1981.
Onex mine				Development deferred.
Thayer Lindsley mine				Development deferred.
Inco Limited, Sudbury	.. Ni(..) Cu(..)		Sudbury	
Copper Cliff North mine		..		Placed on standby, 1978.
Crean Hill mine		..		Placed on standby, 1978.
Fecunis mine				Acquired in an exchange with Falconbridge, on standby.
Levack East mine		..		Development deferred.
Murray mine		..		Placed on standby, 1971.
Totten mine		..		Development suspended, on standby.
Great Lakes Nickel Limited, Pardee Township	66 million Ni(0.20) Cu(0.40)	..	..	Development to bring property on at a rate of 2.25 million tpy have been suspended and the project put on standby, 1974.
Teck Corporation, Montcalm Township	4.5 million Ni(1.4) Cu(0.66)	..	..	Feasibility study completed. Development decision deferred pending an improvement in nickel markets.
Manitoba				
Inco Limited, Thompson	.. Ni(..) Cu(..)		Thompson	
Birchtree		..		Production suspended and placed on standby, 1977.
Pipe No. 1 mine		..		Development suspended 1977, on standby.
Soab		..		Placed on standby, 1971

Source: Energy, Mines and Resources Canada.
.. Not available.

TABLE 5. CANADIAN PROCESSING CAPACITY, 1980

	Inco			Falconbridge	Sherritt Gordon
	Port Colborne	Sudbury	Thompson	Sudbury	Fort Saskatchewan
Smelter (tpy of contained nickel)	n.a.	127 000	81 600	45 000	n.a.
Refinery (tpy of contained nickel)	81 600	56 700	55 000	n.a.	17 500

[1] Reduced from 154 200 t due to a government regulation on SO_2 emissions imposed on September 2, 1980.
n.a. Not applicable.

kilowatt smelting units at Doniambo would be shut down for repair and any decision to resume production would depend on world demand for nickel. SLN had already been producing at only five of its eight 11 000 kilowatt smelting units located in New Caledonia.

In Australia, Western Mining Corporation Limited continued development of the small Carnilyn Hill orebody near Kambalda. The Broken Hill Proprietary Company Limited (B.H.P.) entered into an agreement with Western Mining to acquire a 44 per cent interest in the mine. Selcast Exploration Limited closed its Spargoville mine in January due to exhaustion of known ore reserves.

In China, an expansion was announced at a large, rich nickel-copper deposit in the northwestern province of Gansu. An underground and an open-cast mine began production in the mid-1960s and a new underground mine is now scheduled for development. Some 20 other metals, including gold and platinum, occur in the ore.

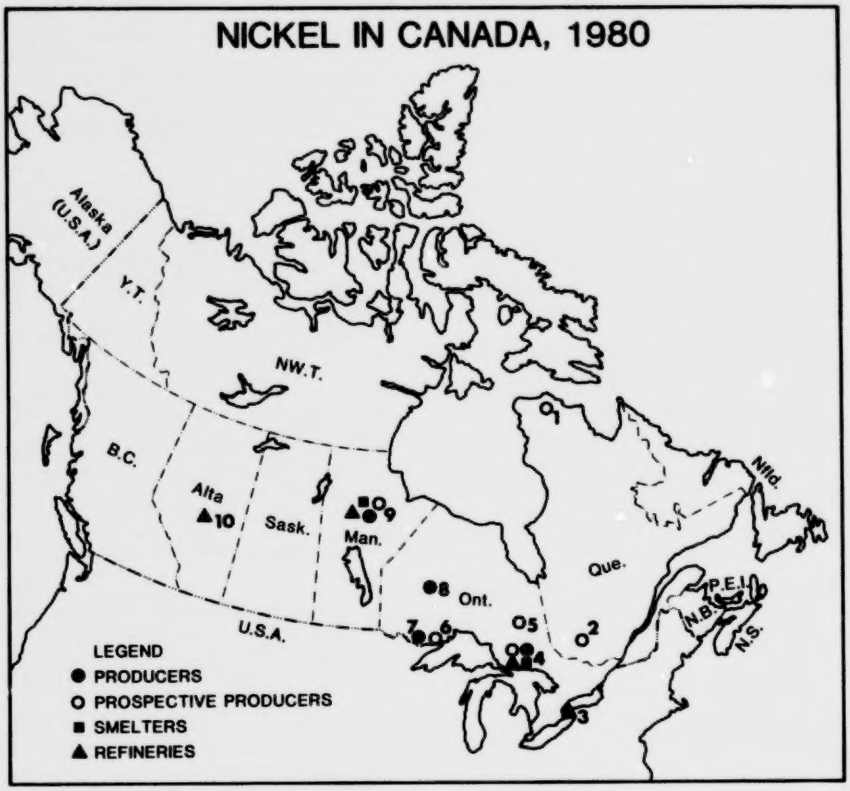
Matthey Rustenburg Refiners (Pty.) Limited continued construction of its new byproduct nickel refinery in South Africa. Capacity is 18 600 tpy and completion is expected late in 1981. The plant will be replacing the present 15 000 t plant.

Preparatory work by Cerro Matosa SA Mine at its nickel deposit in northern Colombia continued, with production scheduled for 1982. The project will have an annual capacity of 22 600 t of nickel in ferronickel grading 35 to 40 per cent nickel. The company has obtained loans totalling $225 million from the World Bank, the U.S. Export-Import Bank and a banking syndicate headed by The Chase Manhatten Corporation. The project is owned by the state nickel company, Econiquel of Colombia, with a 45 per cent interest, Billiton N.V. with 35 per cent and The Hanna Mining Company with 20 per cent. The entire production will be purchased and marketed by the Billiton organization.

TABLE 6. WORLD PRODUCTION OF NICKEL 1979 AND 1980

	1979	1980^e
	(tonnes)	
Canada[1]	126 482	194 947
U.S.S.R.^{e}	150 000	150 000
New Caledonia	82 900	83 600
Australia	73 300	69 800
Philippine Republic	33 300	43 900
Indonesia	37 200	38 800
Cuba^e	35 000	35 000
South Africa	29 500	29 500
Dominican Republic	25 100	15 500
Botswana	16 200	15 400
Zimbabwe	14 600	15 400
Greece	14 600	14 600
United States	12 800	14 500
Guatemala	6 300	6 900
Other	35 800	36 500
Total	693 100	764 300

Sources: Energy, Mines and Resources Canada; World Bureau of Metal Statistics.
[1] Production, all forms.
^{e} Estimated.


NICKEL IN CANADA, 1980
Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
1
2
3
4
5
6
7
8
9
10
LEGEND
● PRODUCERS
○ PROSPECTIVE PRODUCERS
■ SMELTERS
▲ REFINERIES

Producers, prospective producers, smelters and refineries
(numbers refer to locations on map above)

Producers

4. Falconbridge Nickel Mines Limited (East, Falconbridge, Lockerby, North, Onaping, Strathcona)
   Inco Limited (Clarabelle, Coleman, Copper Cliff South, Creighton, Frood, Garson, Levack, Little Stobie, McCreedy West and Stobie)
7. Inco Limited (Shebandowan mine)
8. Union Miniere Explorations and Mining Corporation Limited (Thierry mine)
9. Inco Limited (Pipe No. 2 and Thompson mines)

Prospective Producers

1. New Quebec Raglan Mines Limited
2. Renzy Mines Limited (Hainault Township)
4. Falconbridge Nickel Mines Limited (Craig, Fraser, Lindsley, Onex and Thayer mines)
   Inco Limited (Copper Cliff North, Crean Hill, Fecunis, Murray, Totten)
5. Teck Corporation (Moncalm Township)
6. Great Lake Nickel Limited (Pardee Township)
9. Inco Limited (Soab mine, Birchtree, Pipe No. 1)

Producers (cont'd.)

Smelters

4. Falconbridge Nickel Mines Limited (Falconbridge) Inco Limited (Sudbury)
9. Inco Limited (Thompson)

Refineries

3. Inco Limited (Port Colborne)
4. Inco Limited (Sudbury)
9. Inco Limited (Thompson)
10. Sherritt Gordon Mines Limited (Fort Saskatchewan)

At Inco's refinery at Clydach, Wales, the $23 million fluid-bed roaster and associated sulphuric acid plant which were constructed in late 1978 were officially inaugurated in June. Production of all three major nickel product lines became possible at Clydach, making it the only European refinery capable of these three types of output. A production and craft workers strike which began at Clydach on October 18, 1979 was settled on February 27, 1980, with the signing of a one-year agreement. Flood damage occurred at the plant during the strike and after this was cleaned up the plant operated on two kilns until the end of the third quarter, then on one kiln for the remainder of the year.

The five-month strike at the Port Nickel, Louisiana refinery of AMAX Nickel, Inc. was settled in early January with ratification of a new 32-month contract. Supervisory personnel had been operating the plant at a reduced rate throughout the strike but AMAX was able to supply nickel to its customers from this limited production and also from London Metal Exchange (LME) nickel bought in the fall of 1979.

TABLE 7. WORLD CONSUMPTION OF NICKEL 1979 AND 1980

	1979	1980
	(tonnes)	
United States	183 400	148 300
U.S.S.R.	130 000	130 000
Japan	132 000	119 700
West Germany	77 400	67 200
France	38 900	41 000
Italy	26 700	24 200
United Kingdom	35 000	22 000
China	19 000	19 000
Sweden	22 200	17 900
Brazil	7 900	11 600
East Germany	11 000	11 000
Canada	12 000	10 800
Spain	9 200	9 500
Poland	9 000	9 000
Other	68 900	63 500
Total	782 600	704 700

Sources: Energy, Mines and Resources Canada; World Bureau of Metal Statistics.

Strikes also caused temporary disruptions of nickel production in November at the Trojan mine of Anglo American Corporation of South Africa Ltd. and the Shanghai mine of Johannesburg Consolidated Investment Company, Limited in Zimbabwe. The disruptions lasted for about a week.

WORLD CONSUMPTION

The slowdown in economic activity in North America that spread to Europe and Japan was the main factor behind the decline in nickel consumption in the non-communist world by close to 13 per cent compared with the 1979 level. The 1980 level was 517 000 t. The United States showed the largest volume decline with a drop of 35 100 t to 148 300 t. Consumption in the United Kingdom exhibited one of the largest percentage drops among major consumers, with a decline of 47 per cent to 22 000 t.

Brazil was one of the few countries to record an increase in consumption in 1980. It has averaged an annual compounded growth in nickel consumption of 25 per cent over the past five years. With a relatively young economy, Brazil has reached a higher proportion of capital goods than do more mature economies and this, in combination with a high economic growth rate, has led to strong nickel demand.

Nickel recovered from scrap in the United States, which is the world's largest consumer of nickel scrap, accounted for about 20 per cent of total demand in this market. In the previous year, scrap accounted for 17 per cent of total demand. As overall nickel demand declined in the second half of 1980, a significant buildup of scrap occurred.

TABLE 8. UNITED STATES NICKEL PRICES IN UNITED STATES DOLLARS PER POUND, 1980

	January 1	February 28	February 29	July 9	December 31
Cathodes	3.25	3.50	3.50	3.50	3.50
Pellets	3.20	3.45	3.45	3.45	3.45
Briquettes	3.20	3.45	3.45	3.45	3.45
Falconbridge, ferronickel[1]	3.19	3.44	3.44	3.41	3.41
Hanna, ferronickel[1]	3.15	3.15	3.40	3.40	3.40

Source: **American Metal Market.**

[1] Per pound of contained nickel.

LAW OF THE SEA (LOS)

Resources of polymetallic nodules containing nickel, copper, cobalt and manganese have been known to exist on parts of the deep seabed for many years, but it has taken time to fully appreciate the technical and financial risks associated with the exploitation of these nodules. Only one seabed-mining consortium now states that mining could occur before 1990 and since most projects have slippage in exploration and testing, it would not be surprising if first commercial production occurred at a later date. Aside from questions of technology and economics, the legal regime affecting seabed mining will be a key factor in corporate decisions.

One part of the complex set of negotiations at the United Nations Conference on the Law of the Sea deals with the terms governing access to seabed resources in the international area beyond the limits of national jurisdiction. The convention will allow corporations and an international mining entity called the Enterprise to explore and mine the seabed under agreed plans of work. The Conference ended its ninth session on August 29, 1980. Negotiations between industrialized and developing countries permitted the Conference to resolve questions such as voting in the Council of the International Seabed Authority (where key decisions will require consensus), financing the Enterprise, plans of work for seabed mining, and to a large extent, transfer of technology. Complete agreement could not be obtained among the delegations on production policies, which among other things include: a market access provision, a formula designed to regulate the development of seabed mining, and compensatory financing for developing countries. The current formula puts no restriction on land-based sources. It is designed to establish tonnages for seabed mining which are based on nickel as the control commodity. The United Nations Secretariat is to prepare a study on the production regulation formula which will be reviewed at the tenth session. Overall, the Conference produced a new negotiating text, and also an expectation on the part of many countries present that negotiations could be completed by April 1981, with possible adoption of a convention later in the year.

The United States adopted legislation in June which permits exploration but does not permit ocean mining until after January 1, 1988. The legislation is considered interim and will be superseded when a LOS treaty comes into force. Other major industrialized countries are planning similar legislation.

USES

Resistance to corrosion, high strength over a wide temperature range, pleasing appearance and suitability as an alloying agent are characteristics of nickel which made it suitable for a wide range of applications. The largest use is in stainless steel, which accounts for close to 50 per cent of consumption, followed by nickel base alloys, electroplating, alloy steels, foundry and copperbased alloys. The proportion of nickel used in stainless steel has been growing steadily in recent years.

Close to two-thirds of nickel consumption is in capital goods with the remainder used in consumer products. Nickel is used in chemical and food processing, nuclear power plants, aerospace equipment, motor vehicles, oil and gas pipelines, electrical equipment, machinery, batteries, as a catalyst, and in many other applications.

Relatively new end-use markets that will contribute to nickel's consumption growth in the future are nuclear generating plants, pollution abatement equipment, cryogenic containers, barnacle resisting copper-nickel alloy hull-plating for boats, and nickel-cadmium batteries for standby power applications. A potentially important market is the use of a zinc-nickel oxide battery in electric cars. General Motors Corporation has announced that an electric car utilizing this type of battery will be in production by 1985. However, competition from other battery types such as the zinc-chloride battery being developed by Gulf & Western Industries, Inc. could limit nickel growth in this application. The fledgling solar energy industry could provide a market for increasing amounts of nickel alloys where there is a need for durability and corrosion resistance.

OUTLOOK

Weak nickel demand is expected to continue through the first half of 1981 but, providing the western European and United States economies perform as anticipated, demand should recover slightly during the remainder of the year. Consumers are expected to rebuild depleted inventories, producers deliveries should exceed actual consumption.

No major new nickel capacity will be added in the non-communist world in 1981 to aggravate the current overcapacity. This situation combined with production cutbacks, low consumer inventories, reasonable producer inventories, low rates of return to producers, and the price war experience of 1977-78 (which demonstrated that producer market share does not change significantly with reductions in nickel prices) indicates that further appreciable price erosion should not be expected in the first half of 1981. A pickup in demand in the second half should result in firming of prices.

Nickel consumption increased at an annual rate of only 1 per cent from 1974-79, as opposed to the 1946-73 average of 6 per cent. Consumption is expected to approximate or slightly exceed average real growth in the OECD countries over the next five years and this rate is forecast by various analysts at between 3 and 4 per cent. The versatility of the metal and the key role it plays in a host of industries such as energy, aerospace, transportation, chemical and processing industries, mining and agriculture, and defense will assure significant real growth in nickel consumption, providing reasonable economic growth occurs in western countries. The critical aspect in nickel demand in the 1980s will be the pace at which the major world economies grow and, as part of this, the effectiveness of reindustrialization and other economic measures in some of the major consuming nations.

PRICES

The improvement in the supply-demand balance which occurred in 1979 and resulted in prices being virtually restored to their mid-1977 levels, continued into early 1980. Producer stocks were below ordinary levels early in the year and this, combined with strong demand in the first two months, resulted in Inco's decision to increase prices by nearly 8 per cent effective February 28. Prices, all in U.S. dollars, for melting nickel and plating nickel were raised by 25 cents a pound to \$3.45 and \$3.50 a pound, respectively. Charge nickel was raised 24 cents to \$3.35 in North America, Latin America and the Far East, and to \$3.32 in Europe. Other major producers followed, but the strong market conditions proved to be short-lived as consumption dropped significantly in March. After an increase in consumption of close to 3 per cent in the first two months in the critical United States market, consumption declined sufficiently to bring the overall level for the first quarter to 9 per cent lower than in the comparable 1979 period. Producers instituted certain marketing programs, such as consignment buying, which effectively lowered producers' returns without changing the list price. Various producers had utilized the consignment plan during the weak markets of the mid- to late-1970s to encourage consumers to take delivery of metal but, as an incentive measure, deferring payment for the commodity until after consumption was reported.

Société Métallurgique Le Nickel was one of the few producers to reduce its list price before the November discount announced by Inco. Le Nickel had announced a 4-cent cut in its ferronickel prices for orders after July 1, reducing FN-1 goods to \$3.50 a pound, FN-3 to \$3.47, FNC to \$3.45, FN-4 to \$3.43 and SLN 25 granules to \$3.44.

With the slackening of demand being greater than expected and the reduction in production not being adequate to maintain the expected balance between inventories and consumption, pressure mounted for price reductions, and on November 7, Inco announced a temporary across-the-board discount of 6 per cent. The company stated that nickel was being offered by some major producers at effective prices which were well below list prices offered by Inco and that the discount was needed to remain competitive. The discount applied to orders placed for December and through the first quarter of 1981, after which, if market conditions improved, it would be withdrawn. This initiative was subsequently followed by most other producers.

Prices on the LME were significantly lower than the producer list price during most of the year and in the May to June period the price fluctuated around the $2.70-2.75 range, with a yearly low of $2.64 being obtained. This price was off significantly from the March price of $3.25. The New York dealer price was also substantially lower than the producer list price for most of the year, with a low of $2.80 being recorded.

TARIFFS

CANADA

Item No.		General Preferential	British Preferential	Most Favoured Nation	General
32900-1	Nickel ores	free	free	free	free
33506-1	Nickelous oxide	9.5%	10%	14.7%	25%
35500-1	Nickel and alloys containing 60% or more nickel by weight, not otherwise provided for, viz: ingots, blocks and shot; shapes or sections, billets, bars and rods, rolled, extruded or drawn (not including nickel processed for use as anodes); strip, sheet and plate (polished or not); seamless tube	free	free	free	free
35505-1	Rods containing 90% or more nickel, when imported by manufacturers of nickel electrode wire for spark plugs, for use exclusively in manufacture of such wire for spark plugs in their own factories	free	free	free	10%
35510-1	Metal alloy strip or tubing, not being steel strip or tubing, containing not less than 30% by weight of nickel and 12% by weight of chromium, for use in Canadian manufactures	free	free	free	20%
35515-1	Nickel and alloys containing 60% by weight or more of nickel, in powder form	free	free	free	free
35520-1	Nickel or nickel alloys, namely: matte, sludges, spent catalysts and scrap and concentrates other than ores	free	free	free	free
35800-1	Anodes of nickel	free	free	free	10%
37506-1	Ferronickel	free	free	5%	5%

TARIFFS (cont'd)

CANADA (cont'd)

Item No.		General Preferential	British Preferential	Most Favoured Nation	General
44643-1	Articles of nickel or of which nickel is the component material of chief value, of a class or kind not made in Canada, when imported by manufacturers of electric storage batteries for use exclusively in manufacture of such storage batteries in own factories.	6%	9.6%	9.6%	20%

MFN Reductions under GATT (effective January 1 of year given)

	1980	1981	1982	1983	1984	1985	1986	1987
				(%)				
33506-1	14.7	14.4	14.1	13.8	13.4	13.1	12.8	12.5
37506-1	5.0	5.0	4.8	4.7	4.5	4.3	4.2	4.0
44643-1	9.6	9.2	8.8	8.4	8.0	7.6	7.2	6.8

UNITED STATES

Item No.		
419.72	Nickel oxide	free
423.90	Mixtures of two or more inorganic compounds in chief value of nickel oxide	free
601.36	Nickel ore	free
603.60	Nickel matte	free
606.20	Ferronickel	free
620.03	Unwrought nickel	free
620.04	Nickel waste and scrap	free
620.32	Nickel powders	free
620.47	Pipe and tube fittings if Canadian article and original motor vehicle equipment	free

		1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
419.70	Nickel chloride	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
419.74	Nickel sulfate	4.8	4.6	4.3	4.1	3.9	3.7	3.4	3.2
419.76	Other nickel compounds	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
426.58	Nickel salts: acetate	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
426.62	Nickel salts: formate	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
426.64	Nickel salts: other	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
620.08	Nickel plates and sheets, clad	11.3	10.5	9.8	9.0	8.3	7.5	6.8	6.0
620.10	Other wrought nickel, not cold worked	4.8	4.6	4.4	4.3	4.1	3.9	3.7	3.5

TARIFFS (cont'd.)

UNITED STATES (cont'd.)

		1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
620.12	Other wrought nickel, cold worked	6.7	6.4	6.1	5.9	5.6	5.3	5.0	4.7
620.16	Nickel, cut, pressed or stamped to nonrectangular shapes	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5
620.20	Nickel rods and wire, not cold worked	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
620.22	Nickel rods and wire, cold worked	6.7	6.4	6.1	5.9	5.6	5.3	5.0	4.7
620.26	Nickel angles, shapes and sections	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5
620.30	Nickel flakes, per pound	4.4¢	3.7¢	3.1¢	2.5¢	1.9¢	1.2¢	0.6¢	free
620.40	Pipes, tubes and blanks, not cold worked	2.9	2.9	2.8	2.8	2.7	2.6	2.6	2.5
620.42	Pipes, tubes and blanks, cold worked	3.9	3.8	3.6	3.5	3.4	3.3	3.1	3.0
620.46	Pipe and tube fittings	8.3	7.7	7.0	6.3	5.6	5.0	4.3	3.6
620.50	Electroplating anodes, wrought or cast, of nickel	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
642.06	Nickel wire strand	6.7	6.4	6.1	5.9	5.6	5.3	5.0	4.7
657.50	Articles of nickel, not coated or plated with precious metal	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated 1980, USITC Publication 1011; U.S. Federal Register, Vol. 44, No. 241.

Phosphate

G.S. BARRY

Phosphorus (P) is essential to all plant and animal life. Most soils contain phosphorus in two forms; in the apatite minerals and certain iron and aluminum phosphates, and in organic compounds. As a plant nutrient soil phosphorus is classified as: available with difficulty - most calcium and magnesium phosphates (apatite), some iron and aluminum compounds, and slowly decomposing organic matter; moderately available - some iron, aluminum and calcium compounds and rapidly decomposing organic matter; and readily available - phosphates that are soluble in water and weak acids. Applications of soluble "phosphoric acid" to the soil provide plants with available phosphorus.

Naturally occurring rock deposits are the most common source of phosphorus; other sources are bones, guano, and some types of iron ores that yield byproduct basic slag containing sufficient phosphorus to warrant grinding and marketing.

Phosphate rock, (commonly referred to in the trade as "rock") contains one or more suitable phosphate minerals, usually calcium phosphate, in sufficient quantity for use, either directly or after beneficiation, in the manufacture of phosphate products. Sedimentary phosphate rock, or phosphorite, is the most widely used phosphate raw material. Apatite, which is second in importance, occurs in many igneous and metamorphic rocks and can be represented by the formula $Ca_5(PO_4)_3$ (F,Cl,OH).

Phosphate rock is graded either on the basis of its P_2O_5 equivalent (phosphorus pentoxide) or its $Ca_3(PO_4)_2$ content (tricalcium phosphate of lime or bone phosphate of lime - TPL or BPL). For comparative purposes, 0.458 unit P_2O_5 equals 1.0 unit BPL, and 1 unit of P_2O_5 contains 43.6 per cent phosphorus.

Approximately 80 per cent of world phosphorus production goes into fertilizers; other products which require the use of phosphorus include organic and inorganic chemicals, soaps and detergents, pesticides, insecticides, alloys, animal-food supplements, motor lubricants, ceramics, beverages, catalysts, photographic materials, and dental and silicate cements.

World demand for phosphatic fertilizers increased in 1980 for the fifth consecutive year. Phosphate rock production increased from 130.4 million tonnes (t) in 1979 to 134.9 million t in 1980. Countries principally responsible for the increase were the United States, Jordan, Brazil and the U.S.S.R. Moroccan production decreased for the first time since 1975. World trade in phosphate rock declined, while trade in phosphoric acid and finished phosphatic fertilizers increased; a continuation of the trend to more domestic processing by the producing countries. Western world export sales of phosphate rock decreased from 48.7 to 47.1 million t between 1979 and 1980. In 1980, western Europe continued as the

TABLE 1. CANADA, PHOSPHATE ROCK IMPORTS, 1979 AND 1980

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Imports				
United States	3 256 750	95,846,000	3 816 424	132,680,000
Netherlands	138	7,000	44	32,000
Niger	-	-	26	24,000
Netherlands Antilles	1 586	146,000	-	-
Total	3 258 474	95,999,000	3 816 494	132,736,000

Sources: Energy, Mines and Resources Canada; Statistics Canada.

P Preliminary; - Nil.

principal importer at 21.7 million t (46.1 per cent) followed by Asia, 8.1 million t (17.2 per cent); eastern Europe, 7.3 million t (15.4 per cent) and North America, 4.1 million t (8.7 per cent).

Canada imports all of its phosphate rock requirements, mainly from the United States. Imports in 1980 were 3.8 million t, a 17 per cent increase over 1979. However, about 200 000 t were dedicated to increase depleted stocks. The value of imports was $132.7 million.

In terms of unit value, the price of phosphate rock rose by 18.0 per cent from $29.46 per t in 1979 to $34.78 per t in 1980. This large increase followed a 14.1 per cent price increase the previous year.

OCCURRENCES IN CANADA

Although there are numerous occurrences of low-grade phosphate rock in Canada, there is no commercial production. Currently 3.5 to 4.0 million tpy of phosphate rock is imported, mostly from the United States, for use in the manufacture of agricultural and industrial products sold in the domestic and export markets.

Known Canadian deposits are limited and fall into three main categories: apatite deposits within Precambrian metamorphic rocks in eastern Ontario and southwestern Quebec; apatite deposits in some carbonate-alkaline complexes (carbonatites) in Ontario and Quebec; and Late Paleozoic-Early Mesozoic sedimentary phosphate rock deposits in the southern Rocky Mountains. Phosphatic mineralization was also reported in the layered rocks of the Athabasca series.

The Precambrian metamorphic apatite deposits of Ontario and Quebec occur in pyroxenites as small, irregular, scattered pockets and veins with phlogopite mica and pink calcite. Most of the outcrops are in the Rideau Lakes region of eastern Ontario and the Lièvre River area of southwestern Quebec, where many deposits were worked extensively between 1869 and 1900 before low-cost Florida rock entered world markets.

Carbonatites usually occur as roughly circular plugs intruding older metamorphic rock. In 1975, International Minerals & Chemical Corporation (Canada) Limited (IMCC) began work on a phosphate deposit which was discovered in 1967 in a weathered carbonatite complex in Cargill Township near Kapuskasing, northern Ontario. Some 190 drill holes were completed in 1975-76 and reserves of about 60 million t grading 20 per cent P_2O_5 were outlined. A feasibility study completed late in 1976 indicated that the deposit was sub-economic, but held prospects for future development. In 1979, Sherritt Gordon Mines Limited took a three-year option to buy the property from IMCC. During 1980 the company completed additional drilling and shallow test shafts and conducted an evaluation of the resource base which essentially confirmed previous results. New tonnage and grade calculations were not made public. In excess of $2 million was spent on the project and a full economic evaluation will be conducted during 1981 which will include pilot plant assays. In its evaluation Sherritt Gordon Mines Limited will consider two options; a simple mining operation, and a mine-phosphoric acid plant complex. The attraction of the second alternative in particular is linked to the utilization of nonferrous smelter-based sulphuric acid as a phosphate rock acidulant and is therefore indirectly linked with Ontario's environmental concerns with SO_2 emissions. Pending decisions expected to be made in late 1981 or early 1982, the earliest production could be expected for the 1985-86 period. The importance of this deposit has been sufficiently assessed to forecast that either production will be started in the mid-1980s or plans will be put temporarily on the shelf for production in the 1990s.

Another important apatite-bearing carbonatite is the Nemegos deposit, 24 kilometres (km) southeast of Chapleau, Ontario, held by Multi-Minerals Limited. In 1978 the company reported some 40 million t of mineralized rock of which 5 million t in one zone averaged 70 per cent titaniferous magnetite and 22 per cent apatite and was deemed suitable for open-pit mining. Apatite also occurs in the Oka deposit 32 km northwest of Montreal; the deposit was mined until 1976 for columbium (niobium) by St. Lawrence Columbium and Metals Corporation. Numerous other carbonatite deposits have been identified, some with extensive apatite mineralization but low grades, as indicated in Table 2.

Sedimentary phosphate beds are fairly common in the Rocky Mountains. Most of the exposures occur along the Alberta-British Columbia border between the International Boundary and Banff. Beds at the base of the Fernie Shale have received considerable attention during recent years, since mineable grades and width occur intermittently. Cominco Ltd. retains phosphate concessions in good standing, but plans no further work at present. High cost underground mining methods in poor ground conditions would have to be employed, and phosphate rock imported currently from the United States presents a much more viable alternative than local production, in spite of the fact that development of these deposits would offer considerable transportation savings.

CANADIAN PHOSPHATE INDUSTRY

Phosphate Rock. No production of phosphate rock or phosphate concentrate takes place in Canada and all phosphate rock used by the industry is imported.

Currently, Canada imports approximately 3.5 million t of phosphate rock per year. Imports averaged 3 013 500 t from 1975 to 1981. Approximately 77 per cent of this imported phosphate rock is utilized in fertilizer production, 16 per cent in elemental phosphorus production and 6 per cent in calcium phosphate production. Consumption of rock for the same period averaged 2 950 400 tpy. This is essentially in balance, considering marginal inventory changes (Table 3) and the errors in collecting statistics. Consumption data for years prior to 1975 must be based on import statistics alone because the Statistics Canada consumption series ("from available data") reflected an incomplete coverage of consumers, resulting in a 25 to 40 per cent underestimation.

On a year-to-year basis, consumption of phosphate rock can show large variations depending on the prospects for sale of its principal product - fertilizers. Thus in 1976 and 1977 consumption of rock fell to the unusually low levels of 2.3 and 2.7 million t and imports fell even lower, resulting in a 400 000 t draw-down of stocks that were accumulated in 1975.

Table 4 summarizes phosphate rock imports from 1947 and indicates how Canada relied almost exclusively on supplies from the United States. Import of Moroccan rock was reported in the "other" category from 1962 to 1967, with some spot shipments in 1977 and 1978. Between 2 000 t and 5 000 t of "rock" has been imported from Europe and the Netherlands Antilles (Curacao) in nearly every import year except 1980. This amount represents phosphate imported for direct grinding as animal feed and has been inconsistently recorded either in the "phosphate rock" category or as a product, i.e., calcium phosphate.

About 70 per cent of Canada's imports of phosphate rock from the United States has been from Florida since the late 1970s. The remainder was from western states. Purchase practices, which include commercial factors as well as the characteristics of rock used by the fertilizer plants, point to the continuation of this pattern of supply for at least several years.

Currently, eastern Canada is supplied from Florida (Figure 1). From 850 000 t to 950 000 t are transported by sea, with two-thirds of this total being used for elemental phosphorus production. Low-grade ore (60 to 67 per cent BPL) is purchased for elemental phosphorus production at a plant site at a delivered cost of $45 to $65 per t. Costs of transport average about 40 per cent of the above total. Ocean freight charges are low because rock is shipped as a back-haul to iron ore and other commodities

TABLE 2. PHOSPHATE CONTENT OF CANADIAN CARBONATITES

Complex	Location		Rock type	Approximate range of P_2O_5
	Lat.	Long.		(%)
Argor	50°50'	80°35'	Biotite-calcite carbonatite	2.7- 4.4
Big Beaver House	52°54'	89°55'	Biotite pyroxenite	1.4- 5.3
			Calcite carbonatite	1.7- 2.9
Carb	56°47'	92°00'	Calcite carbonatite	2.3- 4.8
Cargill	49°18'	82°49'	Calcite carbonatite	2.0-10
			Leached carbonatite	10.0-20
			Residuum	20.0-41
Clay-Howells	47°47'	83°08'	Magnetite-calcite carbonatite	1.9- 4.8
Crevier	49°29'	72°45'	Carbonatite	4
Firesand	48°00'	84°40'	Calcite carbonatite	0.1- 5.0
			Dolomite carbonatite	0.3- 3.5
			Mafic rocks	2.5- 7.0
Lackner	46°24'	82°37'	Apatite-magnetite rock	9.2
Mercier	46°44'	75°52'	Calcite carbonatite	1.9- 5.5
Nemegosenda	48°01'	83°05'	Calcite carbonatite	1.7- 3.8
			Mafic rock	1.1- 1.5
Oka	45°31'	74°01'	Carbonatite	1.8-11.6
Prairie	49°02'	86°43'	Calcite carbonatite	1.5- 9.2
			Ijolite	0.9- 8.2
St. Honoré	48°32'	71°10'	Carbonatite	0.5- 6.9
St. Véronique	40°33'	75°01'	Biotite	1.2- 3.6
			Pyroxenite	2.9- 3.2
			Shonkinite	3.2- 4.0
Schryburt	52°36'	89°37'	Calcite carbonatite	2.5- 8.9
			Mafic calcite carbonatite	5.7-14.8
			Leached carbonatite	18.9-19.6
Seabrook	46°59'	83°20'	Calcite carbonatite	1.7- 7.7
			Mafic rocks	0.6- 1.7
Township 109 (Venturi Twp.)	46°38'	81°43'	Biotite-calcite carbonatite	1.0- 4.9

Source: G. Erdosh, "Ontario Carbonatite Province and Its Phosphate Potential", **Economic Geology**, Vol. 74, 1979.

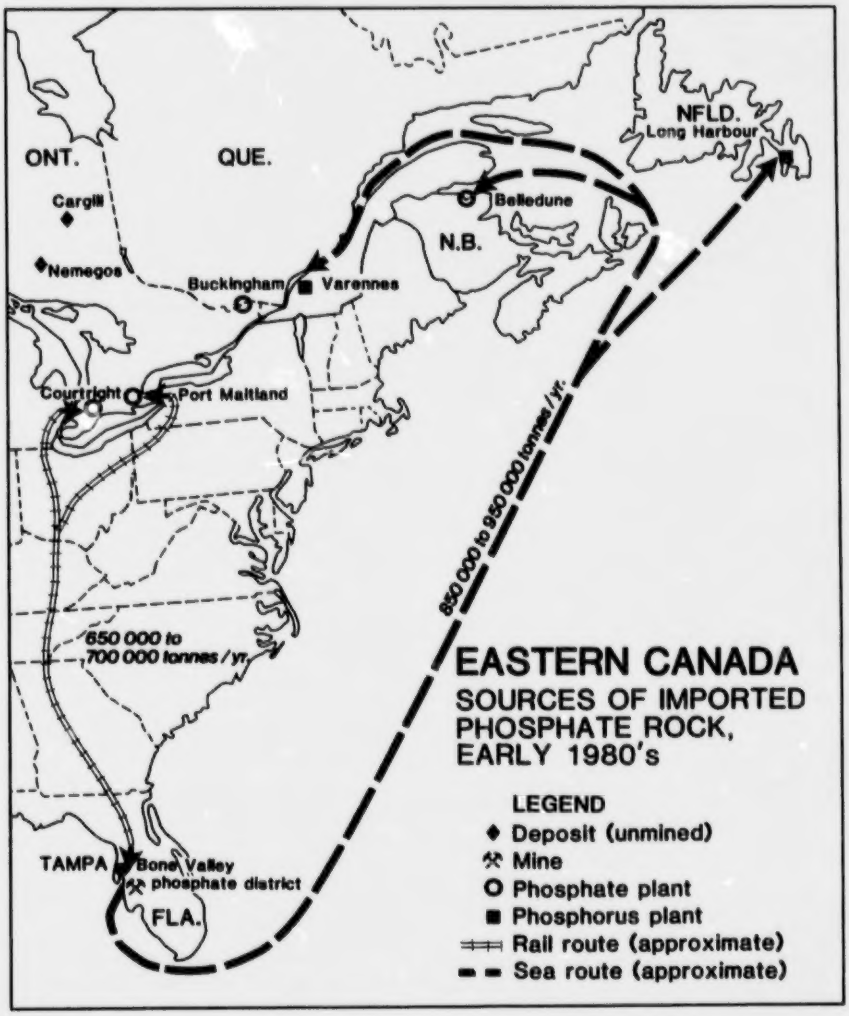

ONT.
QUE.
NFLD.
Long Harbour
Cargill
Nemegos
Buckingham
Varennes
Belledune
N.B.
Courtright
Port Maitland
850 000 to 950 000 tonnes/yr.
650 000 to 700 000 tonnes/yr.
EASTERN CANADA
SOURCES OF IMPORTED PHOSPHATE ROCK, EARLY 1980's
LEGEND
◆ Deposit (unmined)
⚒ Mine
○ Phosphate plant
■ Phosphorus plant
Rail route (approximate)
Sea route (approximate)
TAMPA
Bone Valley phosphate district
FLA.

Figure 1

TABLE 3. CANADA, CONSUMPTION OF PHOSPHATE ROCK

	1975	1976	1977	1978	1979	1980	1981e
			(000 tonnes)				
Total Imports	3 282.3	2 241.1	2 361.6	2 961.4	3 256.8	3 816.4	n.a.
Utilization							
Eastern Canada	1 143.9	994.9	1 201.0	1 256.8	1 342.2	1 581.6	1 519.0
Western Canada	1 652.7	1 340.7	1 523.7	1 772.8	1 861.2	2 030.9	2 090.5
Total	2 796.6	2 335.6	2 724.7	3 029.6	3 203.4	3 612.5	3 609.5

Sources: Imports - Statistics Canada; Utilization - Energy, Mines and Resources Canada from company sources.

shipped to the east coast and gulf coast ports of the United States. Transport charges include a land component, since phosphate rock moves by train 40 to 60 km from various mines of the Bone Valley district to Tampa, Florida. In Canada, the phosphate rock is off-loaded directly from ship at plant site at Long Harbour, Newfoundland, but phosphate destined for Varennes, Quebec is off-loaded at Contrecour and trucked about 30 km to the plant. Phosphate rock costs also include a Florida State severance tax of about $2 per t.

Phosphate rock shipped to the Belledune, New Brunswick fertilizer plant also has a low-cost ocean shipping component and is thus delivered at plant site at prices considerably lower than costs to inland fertilizer plants.

Approximately 650 000 t to 700 000 t of phosphate rock is shipped annually by rail from Florida mines to Ontario fertilizer plants because for this part of Canada direct unit train rail service is more advantageous than ocean shipping combined with short overland hauls. The fact that shipments in Florida do not have to be routed via the congested port of Tampa is another positive factor. Another advantage is that railroad shipments can be maintained at a schedule that allows for very low inventories. In general total costs of phosphate rock delivered at fertilizer plants in Ontario are in the $70 to $80 per t range and costs to New Brunswick can be about 20 per cent lower. Florida is the source of phosphate rock for about 45 to 50 per cent of the six western Canadian fertilizer plants and western U.S. states for some 50 to 55 per cent (Figure 2). However, with expansions in capacity at the Esso Chemical Canada and Sherritt Gordon plants, supplies from Florida and the western states are going to be more evenly distributed in the early 1980s. Rock shipped from Florida via the Panama Canal to Vancouver is mainly transported as back-haul to Canadian lumber (to USA) and potash (to South America) exports. The inland rail haul from Vancouver to the Edmonton area is a back-haul to exports of potash. Total shipping costs are competitive with rail haul from mines in the western U.S. states. Thus the delivered cost of phosphate rock for all users except Cominco is in the range of $d0 per t (plus or minus $3). Average costs to Cominco plants are lower since part of their supply comes from the company's own mine in Montana. All fertilizer plants in eastern and western Canada currently use imported rock grading 68 to 71 per cent BPL. The exception is phosphate rock from the Brock mine of Cominco which is lower grade. All delivered costs of phosphate rock were equalized for 70 per cent BPL grade for the purpose of the cost analysis.

Currently the "rise and fall" in purchase price of rock is about $1.10 for 1 per cent BPL ($US 0.91). Severance tax is not applicable for rock sourced in western states.

Because of various impurities, variations in CaO/P_2O_5 ratio, as well as critical limits in iron, silica and MgO content, the filterability characteristics of phosphate rock from various provenances differ considerably, in most cases requiring major adjustments in the operation of fertilizer plants and in some cases requiring additional capital expenses to plants if rock from another source is to be used.

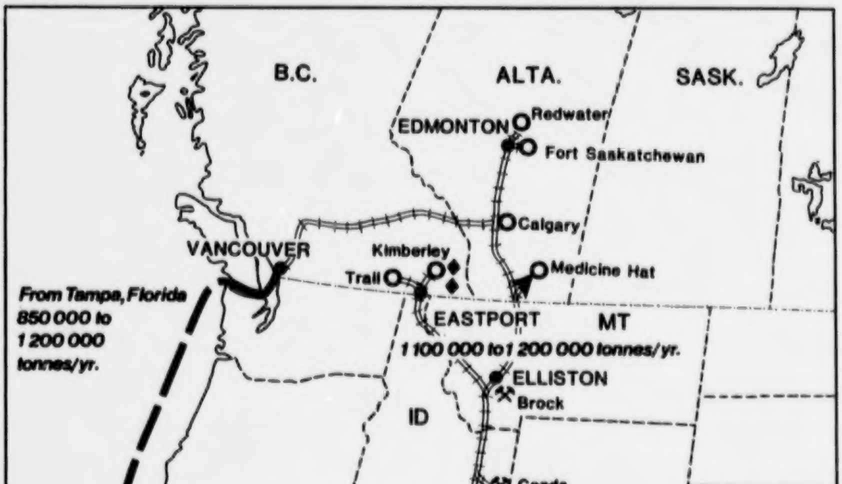

B.C.
ALTA.
SASK.
EDMONTON
Redwater
Fort Saskatchewan
Calgary
VANCOUVER
Kimberley
Trail
Medicine Hat
From Tampa, Florida 850 000 to 1 200 000 tonnes/yr.
EASTPORT
MT
1 100 000 to 1 200 000 tonnes/yr.
ELLISTON
Brock
ID
Conda
Vernal
PHOSTON
UT
WESTERN CANADA
SOURCES OF IMPORTED PHOSPHATE ROCK, EARLY 1980's
LEGEND
◆ Deposit (unmined)
⚒ Mine
○ Phosphate plant
■ Phosphorus plant
Rail route (approximate)
Sea route (approximate)
Baja California

Figure 2

TABLE 4. CANADA, IMPORTS OF PHOSPHATE ROCK

	U.S.A.	Other	Provenance (of "other")	Total
	(tonnes)			
1947	430 873	9 465	2	440 338
1948	432 697	4 572	2	437 269
1949	553 483	9 703	2	563 187
1950	436 868	8 581	2,4	445 450
1951	442 081	11 248	2,6	453 329
1952	415 053	12 152	2,6	427 205
1953	512 831	10 160	2	522 991
1954	567 675	17 330	2,6	585 006
1955	523 468	10 145	2,6	533 613
1956	559 381	10 010	2,4,5	569 391
1957	655 181	911	5	656 092
1958	672 061	3 031	5	675 092
1959	717 472	5 611	5,6	723 082
1960	848 893	5 672	2,5,6	854 565
1961	943 390	15 399	2,5,6	958 789
1962	1 029 568	19 106	1,2,5,6	1 048 674
1963	1 148 534	28 471	1,2,5,6	1 177 005
1964	1 241 724	34 161	1,2	1 275 884
1965	1 532 354	5 590	2	1 537 945
1966	1 884 988	93 889	1,2,4	1 978 877
1967	1 947 358	120 811	1,2	2 068 169
1968	2 127 812	4 052	2	2 131 864
1969	1 992 054	4 958	2	1 997 012
1970	2 229 725	11 064	2,5	2 240 789
1971	2 575 558	4 883	2	2 580 442
1972	2 723 305	5 895	2	2 729 201
1973	3 330 480	6 702	2,5	3 337 182
1974	3 343 139	3 612	2	3 346 751
1975	3 273 086	9 168	2,4	3 282 254
1976	2 236 885	4 201	2,3	2 241 086
1977	2 333 029	28 601	1,2	2 361 630
1978	2 952 737	8 641	1,2,3	2 961 378
1979	3 256 750	1 724	2,4	3 258 474
1980P	3 816 494	70	2,4	3 816 494

Provenance: (1) Morocco; (2) Netherlands Antilles; (3) Israel; (4) Other Africa; (5) Europe; (6) Unspecified.
P Preliminary.

For example, rock from some deposits may require 25 to 30 per cent more filtering capacity or significant additions to dissolving capacity because more time is required for acid digestion of the phosphate rock.

In most regions of Canada the general rock sourced in Florida is competitive with that of western states of the United States but plants utilizing Florida rock would have to incur technical modifications before the sourcing is changed, so that price changes have to be more than nominal. Purchase of U.S. phosphate rock is forecast to continue for the indefinite future. Very substantial changes in the world economics of supply of phosphate rock would have to take place before substantial changes in the practice could occur.

Elemental phosphorus. Erco Industries Limited operates two thermal reduction plants in Canada where elemental phosphorus is produced by the smelting of a mixture of phosphate rock, coke and silica. One tonne of phosphorus requires the input of about 10 t of phosphate rock (60 to 67 per cent BPL), 2 t of coke and 3 t of silica.

Erco has plants at Varennes, Quebec with a 22 500 t annual capacity (P_4) and at Long Harbour, Newfoundland with an effective capacity of about 45 000 tpy. In total, the plants use from 600 000 to 650 000 tpy of Florida phosphate rock. Since the low-grade phosphate rock acceptable for thermal reduction cannot be used by the fertilizer industry, it can be purchased at relatively lower prices (per unit value) and delivered at plants in eastern Canada for $Cdn 45 to 65 per t, depending on specific location and grade. Production at the larger plant at Long Harbour, Newfoundland is shipped mainly to the United Kingdom. Effective capacity has been scaled downward recently with two furnaces in operation. The Newfoundland plant can be upgraded easily to higher production levels as markets are expanded. For transportation to Europe, Erco's parent company, Albright & Wilson, Inc. (a division of Tenneco Inc.), owns two ships for transporting bulk phosphorus. These ships are fitted with hot water-jacketed tanks in which phosphorus is carried under water.

Production from Varennes, Quebec is 90 per cent or more oriented toward Canadian markets. The elemental phosphorus (P_4) produced at Varennes is shipped to two Erco plants, one at Buckingham, Quebec and the other at Port Maitland, Ontario. At Buckingham about 9 000 tpy of P_4 is used to produce technical and food grade phosphoric acid (95 per cent H_3PO_4) and 1 000 t to produce amorphous red phosphorus and phosphorus sesquisulphide.

Red phosphorus and the sesquisulphide are used mainly by the match industry. About 10 per cent of the output is sufficient for the Canadian demand so the rest is exported. These products are valued at over $3,000 per t.

About one-third of the plant's phosphoric acid production is sold commercially and the remainder is used internally to produce various sodium phosphates (about 15 products) calcium phosphate and, since 1980, monoammonium phosphate (MAP). About 80 per cent of the phosphoric acid and derivatives is used by the food industry, while MAP is sold as a fire retardent. Prices of various phosphate compounds range from about $750 to $1,400 per t. Phosphoric acid is sold mainly in grades 75 per cent, 80 per cent and 85 per cent H_3PO_4 but some 105 per cent and 115 per cent is also available. Prices range from about $700 to $1,500 per t depending on grade and purity. There are premiums of between 5 and 10 per cent between technical and food grade acid and of up to 50 per cent on "pure" acid grade.

Erco's Port Maitland plant also operates on phosphorus from Varennes, using about 12 000 tpy. It is all converted to technical grade phosphoric acid only. About 20 per cent is sold, of which one-quarter is exported. The plant also uses acid to produce two products used mainly by the detergent industry; sodium tripolyphosphate and tetrasodium pyrophosphate. About 85 per cent of the phosphate compound is used domestically and 15 per cent is exported.

Coproducts of elemental phosphorus are ferrophosphorus, carbon monoxide and calcium silicate slag. Ferrophosphorus contains 20 to 25 per cent phosphorus and is used by the steel industry as a direct source of the phosphorus needed in some types of steel. It is also used in the manufacture of brake shoes because it provides a rubbing surface without sparking characteristics. The carbon monoxide is used internally as a fuel and the calcium silicate slag is crushed and sold locally as road building material.

Phosphate fertilizers. Phosphate fertilizers are normally produced by decomposing phosphate rock with a strong mineral acid. In Canada only the two most common acidulents, sulphuric acid and phosphoric acid, are used in commercial practice; the former is by far the most common.

When phosphate rock is treated with sulphuric acid, either single superphosphate or phosphoric acid (correctly named orthophosphoric acid, H_3PO_4) is produced. To produce single superphosphate, the rock is treated with sufficient acid to convert the tricalcium phosphate into water-soluble monocalcium phosphate; the coproduct of the reaction, calcium sulphate, remains in the mixture. Normal raw material requirements to produce 1 t of superphosphate, grading 20 per cent P_2O_5 equivalent, are 0.64 t of phosphate rock (70 to 72 per cent BPL) and 0.47 t of sulphuric acid (100 per cent basis).

To produce phosphoric acid, larger quantities of sulphuric acid are added to maintain a fluid slurry that facilitates removal of calcium sulphate by filtering. Phosphoric acid thus produced is termed "wet" phosphoric acid (WPA) to distinguish it from "furnace" phosphoric acid based on elemental phosphorus.

All nine Canadian plants (Table 5) produce wet phosphoric acid by the dihydrate process in which 28 to 30 per cent P_2O_5 acid is the principal product and gypsum is the waste product. At present, there is no use for the gypsum and it accumulates in large settling ponds near all the plants except one in New Brunswick where it is disposed of in the sea.

Canadian phosphoric acid plants are designed to operate on phosphate rock which grades between 69 and 72 per cent BPL (31.1 to 33.0 per cent P_2O_5). The first stage of acid production, which is digestion and filtration, produces "filter acid" grading 28 to 30 per cent P_2O_5. This product is then upgraded by evaporation to about 40 to 44 per cent acid for most in-plant use, or to 52 to 54 per cent P_2O_5 for commercial sales or specialized uses. The evaporation step is energy intensive, and the provenance of sulphuric acid has a bearing on energy consumption. Plants using elemental sulphur as the source of in-plant sulphuric acid production have their evaporation energy requirements met by heat generated in the sulphuric acid plants since the process is exothermic, (i.e., 1 t of sulphur has a BTU content equivalent to about 2 barrels of oil). Plants using commercial sulphuric acid, (e.g., produced from SO_2 smelter gases) have to generate vapour requirements with natural gas or coal fired boilers. To balance energy requirements, an efficient dihydrate WPA plant could theoretically operate using

TABLE 5. CANADA, PHOSPHATE FERTILIZER PLANTS, 1980

Company	Plant Location	Annual Capacity	Principal End Products	Source of Phosphate Rock	Basis for H_2SO_4 Supply for Fertilizer Plants
		(tonnes)	(P_2O_5 eq.)		
Eastern Canada					
Canada Wire and Cable Limited	Belledune, N.B.	150 000	am ph	Florida	SO_2 smelter gas
C-I-L Inc.	Courtright, Ont.	90 000	am ph	Florida	SO_2 smelter gas, pyrrhotite roast and waste acid
International Minerals & Chemical Corporation (Canada) Limited	Port Maitland Ont.	118 000	H_3PO_4,ss ts,ca ph	Florida	Sulphur and SO_2 smelter gas
		358 000			
Western Canada					
Cominco Ltd.	Kimberley, B.C.	86 700	am ph	Montana and Utah	SO_2 pyrite roast
	Trail, B.C.	77 300	am ph	Utah	SO_2 smelter gas
Esso Chemical Canada	Redwater, Alta.	204 000	am ph	Florida	Sulphur
Sherritt Gordon Mines Limited	Fort Saskatchewan, Alta.	50 000	am ph	Florida	Sulphur
Western Co-operative Fertilizers Limited	Calgary, Alta.	140 000	am ph	Idaho	Sulphur
	Medicine Hat, Alta.	65 000		Idaho	
		622 000			
Total, phosphate fertilizer		980 000			

Source: Energy, Mines and Resources Canada.

P_2O_5 eq. Phosphorus pentoxide equivalent; am ph Ammonium phosphates; ss Single superphosphate; ts Triple superphosphate; ca ph Food supplement calcium phosphate; H_3PO_4 phosphoric acid for commercial sales.

elemental sulphur for 70 to 75 per cent of its requirements and purchased sulphuric acid for the remainder.

Plant phosphoric acid (40 to 44 per cent P_2O_5) is transferred to fertilizer production units where it is combined with ammonia to produce various grades of ammonium phosphates. This takes place in eight plants. At the Port Maitland plant of IMCC, however, most of the phosphoric acid is upgraded to 45 to 50 per cent P_2O_5 ("merchant grade"). It is used internally for triple superphosphate and calcium phosphate production or sold commercially.

Most phosphate rock has 3 to 4 per cent fluorine which technically can be recovered as fluosilicic acid. This is the practice in some plants, but on a partial basis, because only limited quantities of fluosilicic acid can be disposed of commercially (for water fluoridation). Since the release into the atmosphere of hydrogen fluoride, which is produced in the WPA process, is detrimental to plants and animals, all fertilizer plants have scrubbing facilities and combine most of the recovered fluorine with waste gypsum for disposal in settling ponds. A portion of the fluorine stays with the phosphoric acid and reports in finished fertilizers where it

TABLE 6. CANADIAN PRIMARY[1] FERTILIZER PRODUCTION

Type	Western Canada	Eastern Canada	Total	P_2O_5 content
		(000 tonnes P_2O_5)		
MAP	780 - 850	110 - 130	890 - 980	445 - 490
DAP	110 - 160	210 - 250	320 - 410	150 - 190
Am. Phosph.	120 - 150	-	120 - 150	25 - 30
Single SP	-	150 - 200	150 - 200	50 - 65
Triple SP			1 480 - 1 740	670 - 775

Source: Energy, Mines and Resources Canada estimates from company data.

[1] Primary, i.e., homogenous phosphatic fertilizers, part of which is used internally to produce mechanically mixed fertilizers NP and NPK.

presents no problems. IMCC, however, completely defluorinates that portion of phosphoric acid which is used for calcium phosphate production for animal feed.

Most phosphate rock contains uranium. It is in small enough quantities not to present any problems for fertilizer production. However, recent high uranium prices generated interest in its recovery. Typical Florida rock, for example, contains 0.007 to 0.02 per cent uranium. As a rule of thumb 0.8 to 1.0 pounds of uranium per t of 100 per cent P_2O_5 phosphoric acid is recoverable. The recovery of uranium takes place at the phosphoric acid stage where organic solvents are used to strip the uranium from the acid. The step requires critical control, since the reagents used, principally a DEPA-TOPO mixture (di-2-ethylhexyl phosphoric acid and tri-n-octyl phosphine oxide) in an aliphatic organic solvent must be completely removed before the acid is directed toward further production of phosphatic fertilizers.

In Canada, Earth Sciences Incorporated (ESI) completed a uranium recovery plant in Calgary in 1980. It treats phosphoric acid from the adjoining plant of Western Co-operative Fertilizers Limited, and returns the acid to the owner. The recovered yellow cake is shipped to the United States. Since uranium prices are currently only about half of the peak achieved a few years ago, construction of similar uranium recovery plants at other fertilizer plants in Canada is not now economic.

Capacity of Canadian phosphoric acid plants is expressed in 100 per cent P_2O_5 equivalent and the total annual capacity is currently estimated at 980 000 t. Efficient plants can consistently operate at 90 to 95 per cent of nameplate capacity. Most Canadian plants, however, gauge their annual production levels to corporate marketing strategies and fertilizer demand forecasts. At times when agricultural demand is low Canadian production capacities are seriously underutilized. Generally there is sufficient Canadian phosphoric acid capacity in place or under active expansion to satisfy domestic market requirements. A small surplus of phosphoric acid is exported by one company, while up to 10 000 tpy are imported from the United States due to regional economics in transport.

The dihydrate wet phosphoric acid process usually allows for the recovery of 90 to 94 per cent of P_2O_5 values contained in the imported phosphate rock. There are some other losses in fertilizer production units so that the overall plant recovery is usually between 88 and 92 per cent.

Calcium Phosphate. Two fertilizer plants in Canada use phosphoric acid for the production of calcium phosphates that are used mainly for supplementing the calcium and phosphorus content of animal and poultry feedstocks.

Defluorinated phosphoric acid, having a phosphorus:fluorine ratio of not less than 100:1 is passed into a reactor where finely ground limestone is added to form calcium phosphate. Two products may be formed, monocalcium phosphate (21 per cent phosphorus) or dicalcium phosphate (18.5 per cent phosphorus). The choice is controlled by the ratio of acid to limestone fed to the reactor.

The phosphoric acid used for calcium phosphate production in eastern Canada is all produced by IMCC in Port Maitland, Ontario. The company uses more than half for its own requirements and sells the remainder to a nearby plant at Welland, Cyanamid Canada Inc., which produces feedstock grade calcium phosphates as well. The two plants produce annually between 100 000 t and 125 000 t which, together with 15 000 t to 20 000 t of imports, account for the total Canadian requirements. This market has been growing steadily at 4 to 6 per cent annually and it is expected that incremental requirements will be available from existing facilities since there are no perceived impediments to expansions in production. Because of local commercial considerations (mainly transportation factors), small quantities of calcium phosphates are imported each year from the United States.

Phosphatic fertilizers. All of the nine phosphoric acid plants in Canada are integrated to produce phosphatic fertilizers, mainly ammonium phosphates. Ammonium phosphates are produced by a neutralization reaction of phosphoric acid with ammonia and, depending on the proportions of the original constituents, either diammonium phosphate (DAP) (18-46-0) or mono-ammonium phosphate (MAP) (range from 11-48-0 to 11-55-0) are produced.

Six western Canadian fertilizer plants (Table 5) produce annually between 780 000 t and 850 000 t of mono-ammonium phosphates (MAP) and between 110 000 t and 130 000 t of diammonium phosphates (DAP). Another popular grade in the west is an ammonium phosphate-sulphate having a composition 16-20-0 or actually 16-20-0-14 if the sulphur content, which is also a nutrient, is taken into account.

TABLE 7. CANADA, PHOSPHATE FERTILIZER SHIPMENTS, 1976-80[1]

	1976/77	1977/78	1978/79	1979/80	1980 July-December
	(tonnes P_2O_5 equivalent)				
Domestic markets:					
Atlantic provinces	25 407	28 578	18 867	19 441	4 534
Quebec	40 554	34 935	23 540	20 992	5 608
Ontario	83 484	78 158	63 379	54 602	21 539
Manitoba	63 008	81 687	89 576	110 382	48 294
Saskatchewan	75 786	110 351	131 636	131 500	77 742
Alberta	105 631	121 531	140 880	131 413	67 010
British Columbia	8 665	9 879	12 440	14 204	3 271
Total Canada	402 535	465 120	480 318	482 533	227 997
Export markets:					
United States	179 699	153 305	144 670	146 813	76 283
Offshore	50 851	31 120	46 814	44 999	73 455
Total exports	230 550	184 425	191 484	191 812	149 738
Total shipments	633 085	649 545	671 803	674 344	377 735

Source: Canadian Fertilizer Institute.

[1] Fertilizer year: July 1 to June 30.

Note: Totals may not add due to rounding.

TABLE 8. CANADA, TRADE IN SELECTED PHOSPHATE PRODUCTS, 1979 AND 1980

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Imports				
Calcium phosphate				
United States	16 149	6,286,000	12 942	5,927,000
Other countries	3 908	883,000	33	26,000
Total	20 057	7,169,000	12 975	5,953,000
Fertilizers:				
Normal superphosphate, 22% or less P_2O_5				
United States	1 600	237,000	4 825	697,000
Triple superphosphate, over 22% P_2O_5				
United States	71 867	10,883,000	45 433	9,911,000
Phosphatic fertilizers, nes				
United States	306 264	62,487,000	196 509	53,699,000
Belgium-Luxembourg	1 320	684,000	1 154	636,000
Israel	697	442,000	459	372,000
Japan	-	-	5	2,000
Trinidad-Tobago	4	2,000	-	-
Total	308 285	63,615,000	198 127	54,709,000
Chemicals:				
Potassium phosphates				
United States	1 086	1,001,000	895	932,000
Israel	91	70,000	80	91,000
France	18	18,000	28	31,000
Other	2	6,000	-	-
Total	1 197	1,095,000	1 003	1,054,000
Sodium phosphate, tribasic				
United States	612	245,000	597	325,000
France	88	29,000	105	33,000
Netherlands	18	5,000	18	6,000
Belgium-Luxembourg	37	9,000	-	-
Total	755	288,000	720	364,000
Exports				
Nitrogen phosphate fertilizers, nes				
United States	418 559	64,813,000	360 889	71,214,000
Belgium-Luxembourg	27 311	5,476,000	51 174	13,736,000
Peoples Republic of China	-	-	21 904	6,354,000
Taiwan	-	-	21 948	4,632,000
Thailand	-	-	17 320	2,985,000
Japan	-	-	5 498	1,414,000
Australia	-	-	5 110	568,000
Pakistan	60 274	12,629,000	-	-
Paraguay	16	11,000	-	-
Total	506 160	82,929,000	483 843	100,903,000

Source: Statistics Canada.
P Preliminary; nes Not elsewhere specified; - Nil.

Eastern Canadian fertilizer plants produce between 110 000 t and 130 000 t of MAP and between 210 000 t and 250 000 t of DAP. The IMCC plant at Port Maitland produces 150 000 t to 200 000 t annually of combined single superphosphate (SSP) and triple superphosphate (TSP).

Canada is essentially self-sufficient in phosphatic fertilizers but due to transport economics a brisk two-way trade exists between Canada and the U.S. For the last four years exports averaged 200 000 t P_2O_5 equivalent and imports only 150 000 t P_2O_5. Exports are mainly from western Canada and New Brunswick and imports mainly into central Canada including Manitoba.

Domestic shipments as well as exports by Canadian producers are documented by the Canadian Fertilizer Institute (Table 7). The data is particularly appreciated because it is provided in a common denominator of P_2O_5 equivalent. Table 8 documents foreign trade in selected phosphate products in product tonnes.

Accurate statistics on total Canadian consumption of fertilizers do not exist. Statistics Canada produced a series that was very useful but it was discontinued in 1977.

Agriculture Canada made a fertilizer consumption estimate for the last four years based on total nutrient NPK[1] intake but did not evolve a separate series for phosphates. The best estimate currently available is that of the Canadian Fertilizer Institute prepared for Agriculture Canada (Table 9).

WORLD DEVELOPMENTS

World phosphate rock production in 1980 is estimated at 134.9 million t, of which western world production was 100.3 million t. Western world production increased 4.6 per cent for the year and since consumption was estimated to have had a lower growth rate of 3.0 to 3.5 per cent phosphate rock, inventories increased. Significant production expansions in many countries are planned for the next one to five years, but those expansions with firm target dates are few. This is somewhat reassuring since the introduction of 25 to 30 million t of incremental capacity, as cumulatively planned, may lead to a temporary overcapacity in the mid-1980s.

Algeria. Société Nationale de Recherches & d'Exploitations Minières (Sonarem), the Algerian government phosphate mining company, operates a large mine at Djebel-Onk and a small mine at Djebel Kouif. Combined capacity is 1.2 million tpy. Product grades from 63 to 65 per cent BPL and about 40 per cent is calcined, raising it to 73-75 per cent BPL, mainly for export. A 165 000 tpy phosphoric acid plant at Annaba operated by Sonatrach uses the lower grade material. By 1985 capacity of the Djebel-Onk mine will be expanded to over 2.0 million tpy. At the same time, Sonatrach plans to bring on stream two new phosphatic fertilizer plants, one at Annaba and one at Tebessa; thus rock exports will be maintained at current levels.

Australia. There was renewed interest during 1980 in the Duchess phosphate mine of Queensland Phosphate Limited. The mine closed in 1978 after four years of operating losses but may be put back into production by mid-1980 because of the uncertainty of supplies from the Christmas Islands.

Brazil. Brazil produced 2.2 million t of rock in 1980 from six mines with a total rated capacity of 2.5 million tpy. All mines produce concentrates from low-grade deposits varying from 7 to 12 per cent P_2O_5 and production costs are among the highest in the world. Nevertheless the Brazilian industry will expand mine capacity to 4.2 million tpy by 1985 through modest expansion at existing mines and by the addition of two new mines: at Ipanema (Serrana S.A. de Mineracao) at 360 000 tpy by 1983 and Anitopolis (Industrias Luchsinger Madolini SA) at 750 000 tpy by 1985-86. All of the Brazilian rock is destined for domestic consumption. A new large phosphoric acid plant of 300 000 tpy was started up in 1980 by Valefertil S.A., raising total capacity (4 plants) to over 0.5 million tpy.

Egypt. The Red Sea Phosphate Co. and the El Nasr Phosphate Co. operate several small mines near Safaga on the Red Sea and Sebaiya on the Nile near Aswan. Total capacity is about 0.8 million tpy. All the production is currently exported but by 1983 a 60 000 tpy phosphoric acid plant and a TSP plant will be put into operation at Abu Zaabal. Egypt has large underground reserves (about 1 billion t) in the Abu Tartur region (New Valley deposits) in its western desert areas. Logistics, including provision of a railway, preclude their development before late 1980s or early 1990s.

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[1] NPK denotes nitrogen, phosphate and potash.

TABLE 9. CANADIAN AGRICULTURAL NUTRIENT CONSUMPTION

Fertilizer Year	East	West	Total
	(000 tonnes P_2O_5)		
1976/77	227.3	275.9	503.2
1977/78	237.0	323.5	560.5
1978/79	255.6	374.7	630.3
1979/80	240.2	387.5	627.7

Source: Canadian Fertilizer Institute (unpublished).

Israel. Production of 2.6 million t of phosphate rock in 1980 is based on four mines operated by Negev Phosphates Ltd. More than half of the production is from the newest Nahal Zin mine that started up in 1978. The mine has a rated capacity of 2.0 million tpy, which will be increased to 3.0 million tpy by 1985-86. The Arad mine will be expanded also by 1985 from 550 000 to 1 000 000 tpy, while the Macktesh mine (350 000 tpy) will be closed, probably before 1985, because of ore exhaustion. Israel's phosphoric acid capacity, currently at 88 000 tpy P_2O_5, will be supplemented by 120 000 tpy P_2O_5 by 1982 with the start-up of a new plant in the Negev Desert (Rotem Fertilizers Ltd.) A second stage, also 120 000 tpy, is planned for production between 1985 and 1987.

Finland. A new phosphate mine of 200 000 tpy was brought on stream in 1980 at Siilinjarvi by Kemira Oy. It is based on an apatite-bearing carbonatite deposit. The ore grades only 4.0 per cent P_2O_5 but will be concentrated to 36 per cent P_2O_5 (79 per cent BPL). A calcite concentrate will be a commercial byproduct.

Jordan. The Jordan Phosphate Mines Co. Ltd. (JPMC) mined 4.2 million t of rock in 1980 from three mines: Rouseifa, Wadi-El-Hassa and Wadi-El-Abiyad. Mining at Wadi-El-Hassa (capacity 1.0 million tpy) started in 1979 and product stockpiled for beneficiation that began in mid-1980. Thus Jordan exported only 3.6 million t in 1980. Jordanian reserves are estimated at over 500 million t and JPMC plans to expand mining capacity to 6.0 million tpy by 1985. Construction at the Jordan Chemical Fertilizer Industry Ltd. (JCFI) complex at Aqaba progressed well into 1980. The

TABLE 10. WORLD PHOSPHATE ROCK PRODUCTION

	1978	1979	1980
		(000 tonnes)	
WORLD TOTAL	**123,187**	**128,745**	**136,014**
West Europe	**137**	**103**	**238**
Finland	–	2	125
France	25	12	10
Sweden	80	62	82
Turkey	32	27	21
East Europe	**24,064**	**24,733**	**25,452**
U.S.S.R.	24,064	24,733	25,452
North America	**50,037**	**51,611**	**54,415**
United States	50,037	51,611	54,415
Central America	**402**	**411**	**330**
Curacao	80	49	–
Mexico	322	362	330
South America	**1,156**	**1,705**	**2,939**
Brazil	1,094	1,695	2,921
Colombia	2	5	4
Peru	–	5	14
Venezuela	60	–	–
Africa	**32,422**	**34,017**	**33,383**
Algeria	997	1,084	1,036
Egypt	642	645	658
Morocco/Sahara	19,678	20,175	18,824
Senegal	1,762	1,804	1,752
South Africa	2,699	3,221	3,282
Togo	2,827	2,916	2,933
Tunisia	3,712	4,040	4,768
Uganda	–	–	–
Zimbabwe	105	132	130
Asia	**12,267**	**13,874**	**17,162**
China	3,200	4,800	6,400
Christmas Island	1,386	1,357	1,638
India	760	645	523
Indonesia	5	5	5
Israel	1,759	2,216	2,611
Jordan	2,303	2,826	3,906
Kampuchea	–	–	5
North Korea	450	450	450
Philippines	4	5	5
Syria	800	1,170	1,219
Vietnam	1,600	400	400
Oceania	**2,702**	**2,291**	**2,095**
Australia	235	7	8
Nauru	1,999	1,838	2,087
Banaba	468	446	–

Totals may not add due to rounding.
Source: British Sulphur Corporation Limited, Phosphorous and Potassium, July-August 1981.

phosphoric acid plant with an installed capacity of 413 000 tpy P_2O_5 will be in commercial production by 1982 with start-up scheduled for the fall of 1981.

Mexico. Low-fluorine phosphate rock is mined at small mines in the State of Nuevo Leon and is exported mainly as an animal feed supplement, while the phosphoric acid industry depends on imports. The first larger mine will be developed by mid-1981 by Rofomex S.A. near San Juan de la Costa on the eastern coast of Baja California. Capacity will be 230 000 tpy and the output will be destined for the Lazaro Cardenas fertilizer complex now under construction on the Pacific coast. By 1981, construction is expected to begin on the Santo Domingo mine (on the western coast of Baja California). A first stage, with a planned capacity of 1.5 million tpy, is slated for production by 1984. If Santo Domingo proves to be an economically viable operation, reserves are sufficient to implement Stage 2 which would result in tripling capacity. Concentrates grading 67 to 69 per cent BPL will be produced from beach sands grading 9 per cent BPL (4.5 per cent P_2O_5). Mexico's phosphoric acid capacity, now rated at about 0.5 million tpy, will be doubled by 1984-85.

Morocco. In 1980 Morocco produced 18.8 million t of phosphate rock, below the peak production of 20.0 million t recorded in 1979. All phosphate production is controlled by the state-owned Office Cherifien des Phosphates (OCP). Mines are currently centred in two regions known as the Oulad-Abdoun and Ganntour deposits which have total reserves in excess of 40 billion t of in situ phosphate rock. In the Oulad-Abdoun region mining has been in progress at Khouribga (east end) since 1922; initially underground and currently mainly open-cast. There are 10 mines in the region, four underground and six open-cast from which ore is transported mainly by conveyors to three large treatment centres at Khouribga, Oud Zem and Ben Idir. Total capacity at Khouribga is about 18 million tpy and it is expected to be increased by about 30 per cent over the next five years. The two largest mines, Sidi Daoui North and South, account for 12.0 million tpy in capacity. Most of the Khouribga phosphate rock grades 70 to 71 per cent BPL. Up to 1.0 million tpy is calcined. Mining on the western exposures of Oulad-Abdoun deposits at Sidi-Hajjaj, approximately 50 km west of Khouribga, is scheduled to start in 1984 at an initial capacity of 3.0 million tpy, which eventually will be doubled. This ore will be shipped to the new port of Jorf Lasfar where it will be washed by seawater and rinsed by freshwater to upgrade the tenor from 60 per cent to 70 per cent BPL.

In the Ganntour region, mining is in progress near Youssoufia (west end) from three open-cast and three underground mines that have a total capacity of about 6 million tpy. Mining will be expanded by 1984-85 to about 8 million tpy, mainly by adding two new underground mines that will produce "black phosphate rock" which grades 68 to 69 per cent BPL and 8 to 10 per cent organic matter and has to be upgraded by calcination to 75 per cent BPL. Mining at the centre of the Ganntour deposits at Ben Guerir about 100 km east of Youssoufia began in 1980 and will reach the initial planned capacity of 2.0 million tpy in 1982. Long-term plans are to expand production to 9.0 million tpy. The phosphate rock grading 62 to 63 per cent BPL is railed to Safi for washing and upgrading to 66 to 67 per cent BPL. Morocco also has large reserves in the Maskala region which may be developed in the late 1980s with assistance from the U.S.S.R. for export to eastern Europe.

There is no indication when the Bu-Craa deposit in former Spanish Sahara will be put back into production. This deposit has a production potential of up to 3.0 million tpy but may remain inactive until the political situation is resolved.

The Office Cherifien des Phosphates operates a large chemical complex at Safi which has been undergoing continuous expansion since 1965. Currently it consists of Moroc Chemie I with four P_2O_5 phosphoric acid units of 125 tpd capacity each; Moroc Chemie II with one 500 tpd unit; Moroc Phosphore I with three 500 tpd units; and Moroc Phosphore II with three 500 tpd units to be put in operation in March 1981. In 1980 the Safi complex used 2.0 million tpy of phosphate rock (from Youssoufia) to produce phosphoric acid for export and downstream fertilizer facilities. A large new phosphate port is now under construction at Jorf Lasfar and will be the site of a large multi-stage phosphate complex to be developed between 1981 and 1990. In September 1980 OCP awarded Rhône Poulenc Industries of France the contract for phosphoric acid plants. Plans call for eight 500 tpd P_2O_5 units with the first to be put in operation by 1983. The timing interval for the start-up of additional units will probably be one to three years depending on market conditions. OCP also announced long term plans to construct a fertilizer chemical complex at Nador on the Mediterranean coast in the late 1980s with four 500 tpd P_2O_5 phosphoric acid units. All these projects mean that by the end of this decade Morocco will use domestically 6 to 10 million t of phosphate rock depending on the progress made in realizing these very ambitious expansion plans.

Senegal. Cie Senegalaise des Phosphates de Taiba produces about 1.2 to 1.5 million tpy for export, and Societe Senegalaise des Phosphates de Thies produced about 300 000 tpy of aluminum phosphate sold as Phosphal rock. There are no plans for expansions in the near future. A small phosphoric acid plant (30 000 tpy) currently operates on calcined rock from Thies. Senegal intends to develop a large fertilizer complex which will include a 200 000 tpy P_2O_5 phosphoric acid plant. Construction is to start in 1981 for production in the mid-1980s. Reserves at the Taiba mine are limited to about 15 years of production and a new deposit at Tobene will be put into production as mining at Taiba is phased out.

South Africa (Republic of). The Phosphate Development Corp. Ltd. (Foskor) produces about 3.0 million tpy of concentrates (78 to 81 per cent BPL) from an igneous complex at Phalaborwa. About 70 per cent of the feed comes from mining an apatite-bearing pyroxenite and a titanium-rich magnetite-apatite pyroxenite known as foskorite; the remaining 30 per cent comes from processing apatite-rich tailings from the nearby copper mine of the Phalaborwa Mining Co. Production could be expanded in the mid-1980s. Mine reserves are very large. Small amounts of phosphate rock are exported but most is domestically consumed. South Africa's phosphoric acid capacity is almost 1.0 million t (4 plants) part of which is assigned for export.

Togo. Compagnie Togolaise des Mines du Benin (CTMB) produces high grade phosphate rock (79 to 80 per cent BPL) from a deposit at Hahotoe at a rate of 3.0 million tpy. Production will be expanded by 20 per cent with the addition of a fifth line at the concentrator by 1982. Although high-grade, the Togolese rock is high in chlorine and is thus not acceptable in many phosphoric acid plants around the world. The Ministry of Industrial Development has a provision for a large fertilizer complex to be "realized" in the 1981-85 plan. It includes a 330 000 tpy phosphoric acid plant. Financing for such a large project has not yet been procured.

Tunisia. Compagnie des Phosphates de Gafsa operates eight mines in Tunisia, of which only one is open-cast. Total mining capacity is 5.8 million tpy of crude ore and beneficiation facilities are 4.6 million tpy. Some of the Gafsa rock is sold for direct application. Tunisian concentration methods include washing and calcining as well as air separation. Most Tunisian mines were recently modernized and production reached a record 4.6 million t in 1980. Further modest expansions in most mines is well under way with the largest expansion scheduled for the Kef es Schfair mine. Tunisian mine production should surpass 5.0 million tpy in 1984.

Phosphoric acid capacity was raised to a total of 750 000 tpy P_2O_5 with the completion in late 1979 of a 330 000 tpy P_2O_5 plant at Gabes by Société Arabe des Engrais Phosphates et Azote (SAEPA). Industries Chimique Maghrebines (ICM) operates two phosphoric acid plants having a total capacity of 252 000 t P_2O_5 and is in the process of increasing this capacity by 165 000 tpy P_2O_5 (target date 1982). Tunisia is also a growing exporter of phosphoric acid and finished fertilizers.

United States. In 1980 marketable phosphate rock production in the United States reached a new record of 54.4 million t derived from 209.9 million t of run-of-the-mine ore. Eighty-seven per cent of this production came from Florida and a single mine in North Carolina and the remainder from Tennessee and the western states of Idaho, Utah and Montana.

Florida mines currently have a capacity of 53.4 million tpy and this capacity can be increased by 15.0 to 20.0 million tpy over the next five years if market conditions warrant. Some of the larger committed expansions are: The Grace-IMC partnership development of the new Four Corners mine by 1982 at 4.6 million tpy (a net increase of 2.3 million tpy for IMC and only 0.9 million tpy for Grace, offsetting a decline in the existing capacity); AMAX Phosphate Inc.'s doubling of capacity to 2.4 million tpy; Beker Industries Corp.'s new mine of 1.1 million tpy by 1981; Farmland Industries, Inc.'s development of a new 1.8 million tpy mine by 1983; and Noranda Mines Limited's intention to open a small 0.5 million tpy operation on lands that were originally mined for high grade rock. Agrico Chemical Co. will close one of its three mines by 1982 but intends to increase output on the other two properties to maintain a capacity of 7.2 million tpy. Estech General Chemicals Corp. that formerly announced that the 3.0 million tpy Duette mine will be put into operation by 1984 was not able to receive necessary permits and postponed this development.

In North Carolina, Texasgulf Inc. operates a 5.0 million tpy mine, the only one in this state. By 1983-84 Agrico Chemical is expected to open a second mine of 3.6 million tpy capacity. During 1980, Agrico purchased a share in this property from North Carolina Phosphate Corp.

The western states jointly produced 4.5 million t in 1980, of which 2.3 million t was for elemental phosphorus production. Stauffer Chemical Co. sold its phosphate mine at Vernal, Utah to Chevron U.S.A. Inc. for $130 million. This company is expected to raise its production substantially over the next few years. It is possible that a new phosphoric acid plant will be based on the Vernal rock and on sulphur that Chevron will recover from a large desulphurization plant now under construction based on Wyoming gas.

U.S.S.R. The Soviet Union produces 24 to 26 million tpy of phosphate rock annually. There is limited information on Soviet plans. Expansion in the main Kola mining camp, which currently produces about 15 million tpy, appears to be only enough to offset declines in existing mines and ore grades.

Emphasis will be placed in expanding production in Kazakhstan mainly on the Kara Tau deposits. New mining is to be started on two locations in Siberia in association with new trans-Siberian rail construction. The first in production will be the Oshurkov deposit (near Ule Ude) followed by Seligda where very large reserves are reported. The discovery of a large deposit in Estonia has recently been reported.

PRICES

Most phosphate rock is purchased under producer-consumer negotiated prices which depart from listed prices in consideration of volume, transportation conditions and local competitive conditions. Phosrock Ltd., a Florida-based marketing organization which represents about two thirds of producers for export markets lists prices as shown in Table 11. Late in 1980 and early 1981, market conditions were soft and prices posted by Phosrock were not acceptable to many consumers. International prices are also quoted by Office Cherifiens des Phosphates (OCP) fob ports of Safi or Casablanca. These are usually $3 to $5 above Tampa prices, the difference reflecting competitive conditions, for "landed" prices to most European destinations.

TABLE 11. LISTED EXPORT PRICES[1] FOR FLORIDA PHOSPHATE ROCK

Grade	January 1979	January 1980	January 1981
	($US per tonne fob Tampa or Jacksonville)		
73/75% BPL	40	47	57
70/72% BPL	37	44	53
68/70% BPL	35	41	50
66/68% BPL	33	39	48
64/66% BPL	31	37	46

Source: British Sulphur Corporation Limited, Phosphorous and Potassium, March-April 1981.

[1] These prices do not include the charge for severance tax in Florida.

OUTLOOK

The outlook for 1981 is for soft phosphate markets for all products as low agricultural prices, high interest rates and a rather slow general uptrend in economic conditions will compel farmers to be skimpy with fertilizer application. An annual application of phosphates is not as necessary as nitrogen since a delay of one year may have a slight detrimental effect on yields as long as the deficiency is made up within the two following seasons. A substantial turn-around in consumption may thus be expected in 1982. Most experts forecast a consumption growth fluctuating between 3.6 per cent and 5.0 per cent for the next few years. A study completed by the Commodity Research Unit (CRU) forecast a world consumption growth for phosphate rock of 4.3 per cent for the decade of the 1980s.

Between 25 and 30 million t of new capacity is planned for the first part of the 1980s, and if most of this expansion takes place, a significant oversupply situation in phosphate rock may develop in the mid-1980s. It could last for two to four years before it corrects itself. There is a strong probability that sulphur and sulphuric acid will be in tight supply for most of the early 1980s. Thus, whereas rock prices may not undergo unusual increases, finished fertilizers may undergo a relatively higher price performance. The availability of sulphur may be the ultimate limit-setting factor in phosphate fertilizer production.

Platinum Metals

S.A. HAMILTON

Canadian production of platinum-group metals (platinum, palladium, rhodium, iridium, ruthenium and osmium) depends on world demand for nickel, as most Canadian production is a byproduct from processing the nickel-copper ores of the Sudbury Basin. During most of 1980, Inco Limited, Canada's leading producer, operated at or near capacity, metals stocks having been depleted by the 1978-79 strike. Toward the end of the year, sluggishness in the world economy caused Inco to trim production to avoid inventory buildup.

CANADIAN OPERATIONS AND DEVELOPMENTS

Canadian production of platinum-group metals in 1980 was more than double that in 1979, while value nearly tripled (Table 1). Production in 1979 was below normal because of the strike at Inco Limited that began in 1978 and was not settled until June 1979, affecting production in both years. Production of platinum-group metals - nearly the last step in the metal extraction process - did not approach normal levels until late in 1979. A **force majeure** declared on shipments of platinum-group metals by Inco Limited was not removed until early 1980.

The two major Canadian producers of platinum metals are Inco Limited, by far the larger, and Falconbridge Nickel Mines Limited. Both have their major operations in the Sudbury district of Ontario. Inco also recovers platinum metals from its mine in the Shebandowan district, northwestern Ontario, and its mines near Thompson, Manitoba. The residue from the refining of nickel and copper ores containing the platinum-group metals is shipped by Inco to its refinery at Acton, England, for the extraction and refining of platinum metals. Falconbridge Nickel ships a nickel-copper matte that contains platinum metals to its copper-nickel refinery in Kristiansand, Norway. The sludge from this operation is shipped to the United States for recovery of the platinum-group metals.

Platinum-group metals recovered from Canadian ores consist of about 43 per cent platinum, 45 per cent palladium and 12 per cent other platinum metals.

The copper ore deposit of Union Minière Explorations and Mining Corporation Limited (Umex) near Pickle Lake, Ontario contains platinum metals and some nickel. These are contained in the copper concentrates produced at the 3 600 tpd concentrator and shipped to Noranda, Quebec for smelting.

For reasons of corporate confidentiality, Canadian consumption of platinum-group metals is not available.

FOREIGN DEVELOPMENTS

The major world producers of platinum-group metals in 1980, in decreasing order of production volume, were the Republic of South Africa, the U.S.S.R. and Canada. Minor producers included Japan, Colombia, Australia and the United States.

TABLE 1. PLATINUM METALS, PRODUCTION AND TRADE, 1979 AND 1980

	1979		1980P	
	(grams)	($)	(grams)	($)
Production[1]				
Platinum, palladium, rhodium, ruthenium, iridium	6 156 716	56,333,561	12 584 000	155,480,000
Exports				
Platinum metals in ores and concentrates				
United Kingdom	4 739 174	46,754,000	12 283 572	177,734,000
United States	38 351	168,000	84 912	1,634,000
France	47 184	191,000	-	-
Brazil	80 900	384,000	-	-
Total	4 905 609	47,497,000	12 368 484	179,368,000
Platinum metals, refined				
United States	854 599	5,063,000	800 386	10,356,000
Brazil	96 732	353,000	134 616	1,044,000
West Germany	37 324	205,000	62 207	497,000
Other countries	747 168	1,568,000	159 032	304,000
Total	1 735 823	7,189,000	1 156 241	12,201,000
Platinum metals in scrap				
United States	1 406 841	14,092,000	998 702	13,845,000
United Kingdom	8 398	49,000	47 339	607,000
West Germany	84 601	935,000	24 385	200,000
Netherlands	-	-	10 109	100,000
France	-	-	15 894	65,000
Japan	31 104	39,000	-	-
Total	1 530 944	15,115,000	1 096 429	14,817,000
Re-export[2]				
Platinum metals, refined and semiprocessed	43 172	359,000	9,176	68,000
Imports				
Platinum lumps, ingots, powder and sponge				
United Kingdom	51 258	882,000	183 635	4,845,000
United States	179 685	2,189,000	175 672	2,796,000
Switzerland	-	-	4 603	103,000
Total	230 943	3,071,000	363 910	7,744,000
Other platinum group metals				
United States	508 231	2,823,000	556 006	4,144,000
United Kingdom	84 819	639,000	130 292	2,344,000
Norway	-	-	9 642	72,000
Switzerland	2 893	13,000	-	-
Total	595 943	3,475,000	695 940	6,560,000

TABLE 1. (Cont'd.)

	1979		1980P	
	(grams)	($)	(grams)	($)
Platinum crucibles[3]				
United States	775 752	15,001,000	517 033	13,960,000
Platinum metals, fabricated materials, not elsewhere specified				
United States	263 229	2,125,000	3 125 682	8,963,000
United Kingdom	429 352	4,131,000	278 158	5,300,000
Netherlands	-	-	11 850	14,000
Total	692 581	6,256,000	3 415 690	14,277,000

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Platinum group metals, content of concentrates, residues and matte shipped for export. [2] Imported and re-exported in the same forms. [3] Includes spinners and bushings.
P Preliminary; - Nil.

World primary production of platinum-group metals is estimated by the United States Bureau of Mines (USBM) to have risen by 4 per cent in 1980 (Table 3). Production increased slightly in both the U.S.S.R. and the Republic of South Africa. These two producers together accounted for 93 per cent of the world output in 1980 while Canada accounted for about 6 per cent.

Platinum metals consumption remained depressed throughout 1980 but speculative demand forced prices of platinum, iridium and, to a certain extent palladium to record high prices. Use in catalytic converters to control automotive exhaust emissions was reduced as the entire North American automotive industry began a prolonged and severe contraction. The jewellery manufacturing industry, a major consumer of platinum, experienced a sharp drop in demand directly attributable to the high price of the metal.

Higher production in South Africa combined with a return to normal production in Canada resulted in a surplus of platinum metals toward the end of the year. The speculative demand that fueled the steep increase in the spot price for platinum, peaking in March at over $US 1000 per ounce, resulted in some metal offtake but this was not sufficient to counteract reduced industrial demand during the year as a whole.

Japan and the United States remained the leading consumers of platinum metals in the non-communist world in 1980. Over the years, Japan has been the world's major consumer of platinum itself, in part because of the popularity of platinum jewellery, while the United States is the leading consumer of the full platinum group. However, the Japanese jewellery market was adversely affected by the sharp price increases and overall Japanese consumption fell to 55 854 kg.

The USBM estimated platinum-group metals sales in 1980 to United States industry at 68 610 kg compared with 85 720 kg in 1979. Percentage sales by weight in 1980 were: platinum, 50.7; palladium, 41.3; ruthenium, 3.5; rhodium, 3.3; iridium, 1.1 and osmium, less than 0.1.

Republic of South Africa. The Republic of South Africa is the only country among the major producers that mines platinum metals-bearing ores primarily for the recovery of these metals. The deposits, which occur in the Merensky Reef of the Bushveld Complex near Rustenberg, also contain some gold, nickel and copper. The platinum-group metals recovered are estimated to be in the following proportion: platinum, 61 per cent; palladium, 26 per cent; and other platinum-group metals, 13 per cent. Small amounts of osmium and iridium are recovered as a byproduct from the treatment of Witwatersrand gold ores.

South African producers do not plan to expand their capacities in the immediate future and have specified that they will try

TABLE 2. CANADA, PLATINUM METALS, PRODUCTION AND TRADE, 1970, 1975-80

	Production[1]		Exports				Imports[4]	
			Domestic[2]		Re-exports[3]			
	(grams)	($)	(grams)	($)	(grams)	($)	(grams)	($)
1970	15 005 188	43,556,597	15 327 731	44,174,000	634 480	2,365,735	1 889 381	3,123,000
1975	12 417 099	56,493,077	15 530 930	50,244,000	538 899	2,928,000	1 896 410	6,061,000
1976	12 964 582	50,143,112	13 726 089	45,319,000	383 972	1,618,233	1 325 319	3,570,000
1977	14 474 687	61,988,406	13 510 044	52,773,000	1 039 540	3,180,000	1 090 520	3,793,000
1978	10 768 428	65,292,791	11 468 007	58,803,000	169 234	334,000	1 747 051	4,643,000
1979	6 156 716	56,333,561	6 641 432	54,686,000	43 172	359,000	826 886	6,546,000
1980P	12 584 000	155,480,000	13 524 725	191,569,000	9 176	68,000	1 059 850	14,304,000

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Platinum metals, content of concentrates, residues and matte shipped for export. [2] Platinum metals in ores and concentrates and platinum metals, refined. [3] Platinum metals, refined and semiprocessed, imported and re-exported after undergoing no change or alteration. [4] Imports, mainly from United States and United Kingdom, of refined and semiprocessed platinum metals, derived from Canadian concentrates and residues, a large part of which is re-exported.
P Preliminary.

TABLE 3. WORLD MINE PRODUCTION OF PLATINUM METALS, 1978-80

	1978	1979P	1980[e]
		(grams)	
U.S.S.R.[e]	94 866 000	99 531 000	99 531 000
Republic of South Africa[e,1]	88 956 000	99 531 000	101 086 000
Canada	10 768 428	6 156 716	12 584 000
Japan	1 062 028	1 063 739	..
Colombia	433 551	467 000	404 000
Australia	404 345	358 000	..
United States	256 479	227 055	187 000
Other countries	206 791	202 490	1 990 000
Total	196 953 622	207 537 000	215 378 000

Sources: U.S. Bureau of Mines, Minerals Yearbook Preprint 1978-79; U.S. Bureau of Mines, Mineral Commodity Summaries, January 1981 for 1980; and Energy, Mines and Resources Canada.

[1] Includes state of Bophuthatswana, a "tribal homeland" established within the political boundaries of the Republic of South Africa.

[e] Estimated; P Preliminary; .. Not available.

TABLE 4. CHANGES IN PRODUCER PRICES

Date	Platinum	Palladium	Rhodium	Iridium
		Price per gram (per troy ounce)		
January 1	$13.50 ($420)	$4.83 ($150)	$25.72 ($800)	$11.25 ($350)
January 29		$5.63 ($175)		
February 11				$12.86 ($400)
February 27		$7.23 ($225)		
March 24				$16.07 ($500)
August 28	$15.27 ($475)		$22.50 ($700)	$19.29 ($600)
December 5		$6.43 ($200)		

Note: In United States dollars.

to tie expansion to contracts with North American and Japanese automakers.

Rustenberg Platinum Holdings Limited, the largest producer of platinum-group metals in the non-communist world, operated three major mines, a smelter and two refineries in the Transvaal district of the Republic of South Africa. Its subsidiary, Atok Platinum Mines (Proprietary) Limited near Pieterburg, operates a mine with a capacity of 1 200 kg of platinum metals a year.

The refining of copper, nickel and platinum metals is carried out in the Republic of South Africa and in the United Kingdom by Matthey Rustenberg Refiners (Pty) Limited, a company owned jointly by Rustenberg and Johnson Matthey, Inc. the marketing agent for Rustenberg's products. Rustenberg operated its facilities at or near capacity throughout the year. Gross revenue from sales exceeded record levels established during the previous year. Some of this was due to increased nickel and base-metal sales.

While all of Rustenberg's production has come from the Merensky Reef, a second reef which contains chrome associated with the platinum-group metals and known as the Upper Group No. 2 Reef (UG2), occurs beneath the Merensky Reef. Rustenberg is continuing its exploration and research program to evaluate mining costs and to develop a process to economically recover both chromium and platinum metals.

Impala Platinum Limited, the second-largest platinum metals producer in the non-communist world, operates a mine-concentrator-smelter complex and a refinery near Rustenberg. Operating levels were reduced toward the end of 1980 as the market softened and the time for completion of the mine expansion program was extended.

In the Transvaal district of South Africa, Western Platinum Limited - jointly owned by Lonrho Limited, Falconbridge Nickel Mines Limited and Superior Oil Company - operates a mine-concentrator-smelter-refinery complex having an annual capacity of 4 666 kg of platinum metals. Western Platinum recovers platinum-group metals using the NIM process developed by the National Institute of Metallurgy. This process reduces treatment time from about four months to 20 days, sharply reduces labour requirements compared with other processes, and lowers capital expenditures because of smaller space requirements.

U.S.S.R. In the U.S.S.R. platinum metals are derived mainly as a byproduct of the processing of nickel-copper ores in the Norilsk region of northwestern Siberia and the Kola Peninsula of northwestern Russia. Some platinum metals are recovered from placer deposits in the southern Urals, once the major source of U.S.S.R. output. A major expansion program is under way to develop nickel-copper deposits in the Norilsk region. The overall program is targeted for completion by 1984 and should result in substantial increases in the production of platinum and palladium. In the past, the U.S.S.R. ores contained a higher proportion of palladium than of platinum. The ratios of platinum metals recovered have been estimated at about 60 per cent palladium, 30 per cent platinum and 10 per cent other platinum metals.

Colombia. Mine production of platinum metals in Colombia declined slightly in 1980.They are recovered as a coproduct from gold-platinum placer operations in the Chaco and Narimo districts.

United States. Primary platinum metals in the United States are derived as a byproduct of copper refining. Production was below normal in 1980 due to prolonged strikes in the copper industry. The United States also recovered a substantial quantity of platinum metals from secondary sources.

Work continued on the platinum-group metal occurrences of the Stillwater Complex in Montana. The Anaconda Company expects to make a final decision on the feasibility of developing its property by the end of 1981. Stillwater PGM Resources, a joint venture of Johns-Manville Corporation and Chevron U.S.A. Inc., expects to make a final decision on developing its property in 1983.

Early in 1981 the United States government identified platinum-group metals as of strategic importance for national defence and expressed concern that stockpile levels were well below the target levels. This raises the possibility of a platinum metals purchase program at some future date. It also gives the United States government an incentive to encourage domestic production from the Stillwater Complex.

RECYCLING

Recycling of platinum metals, especially platinum, is important in the supply of these metals. It is estimated that over 80 per cent of the platinum metals consumed by industry is recycled, a major portion of it being toll-refined. This is important to those industries that use platinum metals in their processes for purposes such as catalysts, as it reduces the effect of high platinum metals prices on the cost of the goods produced.

USES

The main applications for platinum-group metals are in the automotive, electrical, chemical, dental and medical, glass, petroleum and jewellery industries. The industrial use of these metals is based on special properties such as suitability for catalytic activity, resistance to corrosion and oxidation at elevated temperatures, good electrical conductivity, high melting point, high strength, ductility and aesthetic qualities. Platinum and palladium have wide industrial applications, especially in the catalytic field. The others - iridium, rhodium, ruthenium and osmium - are used mainly as an alloying element with platinum and palladium, but small amounts are used individually in special applications.

The jewellery industry is a major consumer of platinum metals in Japan but not in the United States or Europe where gold has been preferred because of its lower price. Major South African producers launched an aggressive campaign in the United States and Europe to promote greater use of platinum metals in jewellery fabrication, but this program was less successful than anticipated because the platinum price exceeded that for gold until December, making platinum jewellery more expensive.

The development of catalytic converters for the control of automotive exhaust emissions created a major new use for platinum and palladium and was responsible for the recent expansion of production facilities in the Republic of South Africa. The Environmental Protection Agency of the United States and the Japanese government have established automotive emission standards that are best attained by the use of platinum and palladium as catalysts in converters. However, higher emission standards originally to come into force in the United States in the 1981 model year have been deferred to the 1983 model year. Actual requirements will depend on a recovery in car sales and on the ratio of small cars to large ones. Sales of platinum and palladium to the U.S. automotive industry in 1980 are estimated at 16 085 kg and 5 490 kg, respectively, down 30 per cent from 24 983 kg and 6 910 kg in 1979.

Platinum-palladium converters now in use do not control nitrogen oxide emissions and, to meet the standards for these, it appears that rhodium will be a third metal in catalytic converters. The rhodium type converter developed to date requires a relatively high amount of rhodium and could not be adopted universally because the supply of the metal cannot meet the potential requirements. Research activities are oriented toward developing a catalytic converter that contains platinum/rhodium in the same ratio as occurs in the South African ores.

Platinum catalysts are used in petroleum reforming for the production of high octane gasoline. A platinum-rhenium catalyst has been found to be effective in this application and is becoming more important with the phased elimination of tetraethyl lead in gasoline. The petroleum industry in the United States consumed 4 480 kg of platinum in 1980 compared with 5 288 kg in 1979.

Platinum alloyed with other platinum-group metals finds wide application as a catalyst in the chemical industry, as in the production of nitric acid from ammonia and oxygen. Platinum metal catalysts are also used in the production of pharmaceutical products and in the food processing industry. Consumption of platinum-group metals in the chemical industry in the United States was 8 851 kg in 1980 compared with 11 306 kg in 1979.

Platinum is used extensively in the electronic industry in printed circuits, electrical furnaces, thermocouples and electrical contacts for telephone equipment. At one time platinum metal only was used in these applications but a palladium-silver alloy containing 60 per cent palladium and 40 per cent silver is now commonly used. Consumption of platinum-group metals in the electrical industry in the United States was 16 365 kg in 1980, compared with 17 828 kg in 1979.

A platinum-rhodium alloy is used in bushings and spinnerets used in the production of fibre glass, synthetic fibres and in the glass manufacturing industry. Much of the platinum metal used in this field is recycled through toll refining. Consumption of platinum-group metals in the U.S. glass industry was 1 950 kg in 1980 compared with 3 291 kg in 1979.

Platinum metals are used in a number of other applications: dental and medical, laboratory equipment, medical research; fuel cells for direct generation of electric current, and crucibles for the growing of laser crystals and synthetic gems. These latter applications are in expanding areas of high technology, so that the requirement for platinum-group metals is likely to increase.

Although the actual consumption of platinum may be small, a socially important recent development is the use of a platinum-based drug to combat advanced stages of certain forms of cancer.

PRICES

During 1980, producer and spot prices were affected by speculative demand for platinum that developed in conjunction with the speculative rush on gold and silver. Platinum prices outstripped those of gold on the spot market, rising to a peak of \$1085[1] on March 5. The fall was correspondingly steep, with the spot price dropping to $510 at the end of March. Fluctuations during the year raised the price to $721 in ea July but by year-end the price was back $578. Producers, realizing that the run-up in the spot price was an aberration, limited increases in the platinum producer price to levels necessary to cover increased costs of production and changes in relative currency values, primarily an increase in the value of the Rand against the U.S. dollar.

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[1] All prices in United States dollars.

Strength in the palladium market at the beginning of the year, when palladium was in demand as a substitute for platinum in the chemical, electrical and automotive industries, was reflected in producer price increases in January and February. This situation was temporary as the slowdown in economic activity cut into demand and as the U.S.S.R. sold palladium to take advantage of the unusually favourable price. Palladium producer prices were rolled back in December 1980.

Demand for rhodium was adversely affected by the slump in the U.S. automotive industry and in the glass and fibre glass industries. This resulted in a price reduction at mid-year.

Demand for iridium was strong particularly during the first half of the year. Consumption increased markedly in both the electrical and jewellery industries, suggesting that there was some substitution of iridium for platinum. However, four producer price increases took iridium well ahead of platinum.

Demand for ruthenium was lower in 1980 than in 1979 and demand for osmium remained miniscule. Producer prices for both metals, $1.45/g ($45/oz) for ruthenium and $4.90/g ($150-$155/oz) for osmium, were unchanged during the year.

OUTLOOK

The growing demand that developed for platinum-group metals in the 1970s is expected to continue in the 1980s. Platinum has been mainly an industrial metal and large stocks have not been built up because over the years supply and demand have been maintained in close balance. To ensure an adequate supply for industrial requirements, South African producers have raised their output to near their present capacities. Sales by the U.S.S.R. to the west are made in accordance with its own priorities and are not always related to world demand. Exports of platinum and rhodium from the U.S.S.R. to the United States and Japan decreased sharply in 1980. U.S.S.R. sales of palladium, strong during the early part of the year, were reduced as the price deteriorated. The U.S.S.R. is the leading world producer of palladium (due to the high palladium-to-platinum ratio in its ores). There is at present no shortage of palladium and none is anticipated.

The price of platinum should remain strong during the early 1980s. The structure of the platinum industry is such that high prices will be slow to generate significant amounts of extra metal from producers, scrap dealers and speculators. The South African producers estimate that it will take three to four years to increase capacity and capital costs will be high. The producers are seeking some assurance that capital expenditures can be recovered before committing themselves to major programs.

In the medium to long term, the platinum metals industry faces a number of uncertainties. It is not known to what extent the recycling of platinum metals in scrapped automotive catalytic converters will affect the overall supply. Some sources suggest that 9 300 to 13 900 kg could be recovered annually from converters by the mid-1980s, while others question whether the metals can be economically recovered. Advances and improvements in catalytic converter technology could reduce the platinum metals load factor. If the price of platinum becomes excessive there is the possibility of substitution. Applications that are now in the initial stages of development may, within the decade, become major users of platinum group metals. In particular, development of the fuel cell as an important source of electrical power could generate demand for large quantities of platinum. However, the platinum electrodes in fuel cells are recyclable, so that once initial demand is satisfied, replacement fuel cells would use recycled platinum. Other major growth areas are likely to be in the electrical and electronics industry and the chemical processing industry.

In the United States, renewed attention is being given to strategic stockpiles, now referred to as defence materials inventories. The target for platinum is 40 741 kg toward which there is 14 077 kg in storage. Comparable figures for palladium are 93 300 kg and 38 100 kg and for iridium 3 050 kg and 530 kg. Buying programs to raise the stockpiles to target levels could sustain the market in time of weakness or put upward pressure on prices if stockpiling coincides with improved industrial demand.

In the long term, consumption of platinum metals should show steady growth. The large reserves of these metals contained in the Merensky Reef in the Republic of South Africa and Bophuthatswana can be developed to ensure balanced supply and demand. Failure by producers to ensure ample supplies of the platinum metals would encourage consumers to find substitutes.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
36300-1	Platinum wire and platinum bars, strips, sheets or plates; platinum, palladium, iridium, osmium, ruthenium and rhodium, in lumps, ingots, powder, sponge or scrap	free	free	free	free
48900-1	Crucibles of platinum, rhodium and iridium and covers therefore	free	free	15%	free

UNITED STATES MFN Reductions under GATT (effective January 1 of year given)

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
					(per cent)				
601.39	Precious metals ores	Remains free							
605.02	Platinum metals, unwrought, not less than 90% platinum	Remains free							
605.03	Other platinum metals, unwrought	18.5	17.1	15.6	14.1	12.6	11.2	9.7	8.2
605.05	Alloys of platinum, semi-manufactured, gold-plated	23.1	21.3	19.4	17.5	15.6	13.8	11.9	10.0
605.06	Alloys of platinum, semi-manufactured, silver-plated	11.3	10.6	9.9	9.3	8.6	7.9	7.2	6.5
605.08	Other platinum metals, semi-manufactured, including alloys of platinum	18.5	17.1	15.6	14.1	12.6	11.2	9.7	8.2
644.60	Platinum leaf	18.5	17.1	15.6	14.1	12.6	11.2	9.7	8.2

Sources: The Customs Tariff and Commodities Index, January 1980. Revenue Canada; Tariff Schedules of the United States Annotated 1980, USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241.

Potash

G.S. Barry

Stability at very profitable levels is the best way to characterize the 1980 markets for the Canadian potash industry. A new production record and a total revenue record of $986 million were achieved. Potash mines kept production up near effective capacity utilization, with output 8.7 per cent higher than in 1979 at 7.30 million tonnes (t) of K_2O equivalent (12 million t of products).

Early in the year drought in North America reduced fertilizer application, which was reflected particularly in a very poor sales record for the second quarter that resulted in rapidly increasing inventories. However, a lower production level and an upswing in sales, particularly in offshore exports in the third quarter, stabilized the situation. Sales continued at a normal level in the last quarter, ending the year on an upbeat trend. However, indications for 1981 are not that propitious, with agricultural sales greatly influenced by continuing high interest rates and low farm commodity prices.

Offshore exports at 2.17 million tonnes were 17 per cent higher than in 1979. This high level was achieved despite a very poor first quarter due to transportation disruptions caused by a marine accident that blocked the Second Narrows Bridge in Vancouver, curtailing both rail shipments and usage of the port facilities.

Canadian producers' stocks began the year at a very low 377 700 t, reached a peak of 1 040 500 t at the end of June and declined rapidly to 563 500 t by the end of 1980. At the end of February 1981 inventories were up again, at 771 000 t.

Potash prices during 1980 were firm, particularly on the export markets. Canadian producers averaged a return of about $Cdn 130 per t K_2O compared to $Cdn 95 during 1979.

PRODUCTION AND DEVELOPMENTS IN CANADA

Saskatchewan. There are 10 potash mines in Canada, all in the Province of Saskatchewan. At the end of 1980 total installed capacity was 7 895 000 t K_2O or 12 943 000 t of muriate of potash or KCl. The industry produced 7.3 million t of potash operating at 92.4 per cent of capacity. Shipments, however, were higher at 7 523 000 t. Shipments are commonly referred to as "production" in most statistical publications. The value of shipments in 1980 was $986 million. Average realized price by the mines was $131 per t of K_2O or $79.90 per t of KCl. Employment in the potash industry increased from 3,750 persons in 1979 to 4,200 in 1980.

In order to exercise direct control over the potash industry in Saskatchewan, the provincial government decided in 1975 to nationalize part of the industry. The Potash Corporation of Saskatchewan (PCS) was established by an Order-in-Council on February 4, 1975 and continued under the Potash Corporation of Saskatchewan Act of April 1, 1976. Two subsidiary companies were incorporated under the Companies Act of the Province of Saskatchewan: Potash Corporation of Saskatchewan Mining Limited (PCSML): Cory Division, Rocanville Division, Lanigan Division, Allan Division

TABLE 1. CANADA, POTASH PRODUCTION, SHIPMENTS AND TRADE, 1979 AND 1980

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Production, potassium chloride				
Gross weight	10 982 136	..	11 950 063	..
K_2O equivalent	6 704 728	..	7 292 824	..
Shipments				
K_2O equivalent	7 074 388	735,246,584	7 523 000	986,220,000
Imports, fertilizer potash				
Potassium chloride				
United States	2 033	281,000	28 882	2,595,000
United Kingdom	8	5,000	8	8,000
West Germany	2	1,000	-	-
Total	2 043	287,000	28 890	2,603,000
Potassium sulphate				
United States	20 094	2,435,000	9 414	1,208,000
United Kingdom	12	21,000	-	-
Total	20 106	2,456,000	9 414	1,208,000
Potash fertilizer, nes				
United States	49 626	3,947,000	44 550	4,660,000
Potash chemicals				
Potassium carbonate	1 117	631,000	1 140	673,000
Potassium hydroxide	3 856	1,637,000	4 172	2,022,000
Potassium nitrate	3 172	978,000	2 863	1,092,000
Potassium phosphate	1 197	1,095,000	1 003	1,054,000
Potassium bitartrate	-	-	-	-
Potassium silicates	866	411,000	851	461,000
Total potash chemicals	10 208	4,752,000	10 029	5,302,000
Exports, fertilizer potash				
Potassium chloride, muriate				
United States	7 716 177	512,761,000	7 140 812	596,847,000
Brazil	545 065	40,105,000	787 905	81,023,000
Japan	673 026	46,503,000	629 983	61,816,000
India	313 303	22,731,000	489 739	50,879,000
People's Republic of China	321 969	21,844,000	346 847	37,416,000
Singapore	362 412	26,043,000	262 738	27,893,000
South Korea	255 810	17,331,000	238 355	25,428,000
Australia	133 515	9,187,000	187 560	18,259,000
Taiwan	88 904	5,842,000	167 352	16,227,000
South Africa	41 290	3,644,000	59 729	6,239,000
Other countries	191 227	14,563,000	226 540	24,066,000
Total	10 642 698	720,554,000	10 537 560	946,093,000

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; - Nil; .. Not available; nes Not elsewhere specified.

and Esterhazy Division; and the Potash Corporation of Saskatchewan Sales Limited (PCSSL).

Between 1976 and 1978 PCS acquired 38.5 per cent of the potash-producing capacity of the Saskatchewan mines for a total of \$530 million. In addition, to the end of 1980 the corporation has spent in excess of \$150 million to rehabilitate some of the mines and add to the capacity of others. PCS currently accounts for 40.2 per cent of installed capacity.

In 1980 PCS produced 4.48 million t of KCl, 37.4 per cent of the total provincial production, and reported sales at \$392.5 million from which an income of \$167.5 million was derived after payment of \$89.5 million in provincial taxes, royalties and resource payments. The corporation had an employment roll of 1,944 at year-end of which 1,725 were with PCSML.

By the end of 1980, expansion aimed at removing bottlenecks had been completed at Cory, Rocanville and Allan divisions. By the end of 1981, Phase I expansion at Lanigan and Phase II at Rocanville will be completed, raising overall production capacity to 5.62 million t KCl. (The lower 5.48 million t KCl corresponding to 3.34 million t K_2O in Table 7 represents an average estimate for the calendar year rather than year-end figures.)

PCS intends to spend \$2.5 billion under a 10-year plan announced in October 1980. A major part of this program is the \$430-million expansion at Lanigan scheduled for completion by the end of 1983 which will raise productive capacity of this mine from 545 000 t K_2O in 1980 to 1.74 million t K_2O (2.9 million t KCl). Another project is the proposed new mine at Bredenbury that could come on-stream in 1986 at a capacity of 1.96 million t K_2O (3.27 million t KCl). An Environmental Impact Assessment Study will be completed in 1981 before final approval for the project is granted.

PCS has the objective to produce 11.34 million t KCl by 1990. At 90 per cent capacity utilization this would require about 12.5 million t KCl or 7.62 million t K_2O installed capacity. This is only slightly at variance with the projected capacity of 7.48 million t shown in Table 7. Some proposed expansions are predicated on agreements between PCS and the private industry partners and are not firm commitments. It is likely, however, that unrealized expansion opportunities at any particular mine will have to be compensated for by higher expansions at other mines. Furthermore, incremental expansion has unit costs that are substantially lower than those of a new mine and are likely to be maximized as a first priority for total capacity additions. Entirely private mines committed to expansions during the period from 1980 to 1983 are Cominco Ltd., PPG Industries Canada Ltd. and the Potash Company of America (PCA). Cumulatively they will add 415 000 t K_2O in capacity. Noranda Metal Industries Limited (Central Canada Potash division) has a proposal for an expansion of 220 000 t K_2O for late 1983 but this project has not yet been approved by the government. Texasgulf Inc. and International Minerals & Chemical Corporation (Canada) Limited (IMCC) have the potential to expand their existing operations for a later period, i.e., 1984-86 but these plans are not firm and depend on the principal partner, PCS. All of these incremental expansions were made possible by capital tax allowances negotiated with the province in 1979 under five-year resource payment agreements.

At the beginning of 1979 a number of court cases brought against the Province of Saskatchewan by independent corporations were still pending. These challenged the validity of the "reserves tax", the potash prorationing fee, increases in royalties, etc. Intense negotiations between the provincial government and the industry arrived at a compromise and all litigation effectively ended in October and November when all six private potash producers signed a five-year agreement known as the "Potash Resource Payment Agreement".

Under the agreement, which took effect rectroactively as of July 1, 1979, the producer pays to the province a "base payment" and a "graduated payment". The regulation stipulates that the base payment shall be the sum of:

(a) \$6.00 per K_2O short ton for the first 300,000 K_2O short ton of saleable potash produced from the mine during each year; and

(b) \$7.50 per K_2O short ton for each additional K_2O short ton of saleable potash produced from the mine during the year.

Permitted deductions are related to Crown royalty payments, and royalties payable to the owner of freehold lands.

TABLE 2. CANADA, POTASH PRODUCTION AND SALES BY GRADE[1] AND DESTINATION, 1979 AND 1980

	1980						1979
	Standard[2]	Coarse	Granular	Soluble	Chemical[3]	Total	Total
	(tonnes K_2O equivalent)						
Production	1 958 712	2 747 881	1 765 109	758 638	69 894	7 300 234	6 714 670
Sales							
Domestic	24 752	252 265	86 042	14 633	..	377 692	378 969
United States	653 820	2 036 265	1 344 673	528 289	..	4 563 047	4 930 867
Offshore							
Australia	6 677	55 958	39 349	227	..	102 211	123 487
Bangladesh	18 143	-	-	-	..	18 143	47 620
Brazil	75 246	262 693	153 880	-	..	491 819	367 797
Chile	2 934	-	-	17 372	..	20 306	13 498
China	246 805	-	-	-	..	246 805	159 819
Colombia	828	-	-	-	..	828	-
Costa Rica	6 468	1 643	-	-	..	8 111	3 347
Denmark	14 201	-	-	-	..	14 201	16 015
India	284 669	-	-	3 302	..	287 971	213 135
Indonesia	21 324	-	-	-	..	21 324	13 074
Italy	-	-	-	8 997	..	8 997	20 162
Japan	215 394	82 521	3 035	99 256	..	400 206	422 817
Korea	150 470	-	-	-	..	150 470	156 801
Malaysia	103 875	-	-	-	..	103 875	104 864
Mexico	49 786	-	-	-	..	49 786	12 740
New Zealand	31 618	-	-	-	..	31 618	19 746
Nicaragua	-	-	3 640	-	..	3 640	-
Philippines	45 880	-	-	-	..	45 880	39 468
Romania	28	-	-	-	..	28	23
Solomon Islands	-	-	-	-	..	-	138
South Africa	6 087	17 891	6 196	-	..	30 174	16 566
Sri Lanka	30 127	-	-	-		30 127	20 367
Swaziland	-	-	9 260	-	..	9 260	8 183
Taiwan	93 612	-	-	-	..	93 612	65 072
United Kingdom	626	-	-	-	..	626	872
Offshore total	1 404 798	420 706	215 360	129 154	..	2 170 018	1 845 611
Total sales	2 083 370	2 709 236	1 646 075	672 076	..	7 110 757	7 155 447

Source: Potash and Phosphate Institute.

[1] Common specifications are: standard -28 to +65 mesh, special standard -35 to +200 mesh, coarse -8 to +28 mesh, granular -6 to +20 mesh, each grading a minimum of 60 per cent K_2O equivalent, soluble and chemical grade a minimum of 62 per cent K_2O equivalent. [2] Standard includes Special Standard, production of which was 205 829 tonnes K_2O equivalent in 1980, and 218 978 in 1979, and sales of chemical grade. [3] Chemical sales are included in standard grade sales and totalled 61 841 tonnes in 1980.
- Nil; .. Not available.

There is also a provision for deductions against the base payment if gross mine revenue of the preceding year is low.

The graduated payment is specified to be the aggregate of the following amounts:

(a) 10% of the lesser of:

- i) the producer's operating profit for the year; and
- ii) 5% of the producer's capital investment account as at the end of the year;

(b) 20% of the lesser of:

- i) the producer's operating profit for the year less 5% of the producer's capital investment account as at the end of the year; and
- ii) 10% of the producer's capital investment account as at the end of the year;

(c) 30% of the lesser of:

- i) the producer's operating profit for the year less 15% of the producer's capital investment account as at the end of the year; and
- ii) 10% of the producer's capital investment account as at the end of the year;

(d) 40% of the lesser of:

- i) the producer's operating profit for the year less 25% of the producer's capital investment account as at the end of the year; and
- ii) 10% of the producer's capital investment account as at the end of the year; and

(e) 50% of the producer's operating profit for the year less 35% of the producer's capital investment account as at the end of the year.

A provision allows the application of some credits in deductions for the "base payment" scheme to be transferred to the "graduated payments" scheme. There is an allowance in lieu of depreciation equal to 4.5 per cent of the "opening investment account" (an account that includes most of the past capital expenditures incurred by the mine prior to July 1, 1979). There is also an allowance equal to 10 per cent of the additional capital invested during the tax year.

The Canadian Potash deposits are the most extensive in the world. One of the recent United States Geological Survey publications, **Mineral Commodities Summaries - 1980,** places world reserves at 13.2 billion short tons, of which 2.7 billion tons are in Canada. Reserves estimated by Energy, hines and Resources Canada are much higher - 56 billion t of recoverable K_2O equivalent. In Saskatchewan and parts of Manitoba, potash beds that can be mined by "conventional" methods, i.e., to a maximum depth of 1 070 metres (m) underlie approximately 29 000 square kilometres (km^2).

TABLE 3. CANADA, POTASH PRODUCTION AND SALES BY QUARTERS, 1980

	1st quarter	2nd quarter	3rd quarter	4th quarter	Total 1980
			(000 tonnes)		
Production	1 904.8	1 928.6	1 535.5	1 931.3	7 300.2
Sales					
North America	1 111.0	1 072.9	1 198.0	1 562.4	4 944.3
Offshore	355.9	630.9	758.2	425.1	2 170.0
Ending Inventory	815.6	1 040.5	619.8	563.5	563.5

After making various allowances, including a 20 per cent recovery factor, it was calculated that 360 000 t of product (K_2O equivalent) per km^2 can be recovered. Based on a single bed recovery, this would place reserves at 10.5 billion t; however, since about one-third of the area is underlain by two mineable beds, this estimate of "conventional" reserves was raised to 14 billion t. In addition, "solution mining" reserves (at depths of 1 070 to 2 500 m) are known to be much higher; conservatively at least three times the "conventional" reserves, or 42 billion t.

The Potash Corporation of Saskatchewan is constructing a $1.3 million pilot plant for the production of potassium sulphate at the Cory mine. The pilot plant will utilize potassium chloride and sodium sulphate to manufacture potassium sulphate. If this new process proves successful PCS would construct a plant with an annual capacity of 100 000 t or more.

Other Provinces. In New Brunswick, Potash Company of America completed its underground exploration program in the Sussex mine and announced officially that it will be put into production by early 1983. Initially, output will be at about 680 000 t of product (KCl) but reserves are sufficient to raise production fairly rapidly if market conditions warrant. Capital costs will be in the $150 million range and permanent employment will be 250. Construction employment will peak at 600. The company intends to return waste salt as fill into the mine and will also extract high-purity salt in a separate section of the mine for marketing in New Brunswick and the eastern U.S. seaboard, while making room for excess waste salt that has to be returned to the mine. Plans for a bulk loading facility at Saint John are being finalized.

Denison Mines Limited is sinking a shaft at another potash deposit in Kings County and expects to make a decision on production in 1981. Late in 1980 Denison entered into an agreement with Potash Company of Canada Limited (Potacan), a company jointly owned by West German and French interests, to form a new company, Denison-Potacan Potash Company, in which Denison will have 60 per cent and Potacan 40 per cent interest. Denison will be responsible for mining the potash and Potacan for marketing it. Pending a positive production decision the mine would commence production in 1984 at an initial capacity of about 0.9 million t of product (KCl) and capital costs of over $200 million. Within three to four years the capacity would be raised to 1.35 million t KCl. Employment is expected to be between 300 and 325 and construction will peak at about 700.

TABLE 4. CANADA, POTASH PRODUCTION AND TRADE, YEARS ENDED JUNE 30, 1970, 1975-1980

	Production[2]	Imports[1,2]	Exports[2]
	(tonnes K_2O equivalent)		
1970	3 565 837	24 512	3 309 758
1975	5 063 635	28 764	4 583 648
1976	4 833 296	16 445	4 314 150
1977	4 803 015	24 289	4 175 473
1978	6 206 542	26 095	5 828 548
1979	6 386 617	21 819	6 256 216
1980P	7 062 996	20 620	6 432 124

Source: Potash and Phosphate Institute, Canadian Fertilizer Institute.

[1] Includes potassium chloride, potassium sulphate, except that contained in mixed fertilizers. [2] Change of data source. Prior to 1978 figures were obtained from Statistics Canada.
P Preliminary.

The British Petroleum Company Limited (BP) acquired exploration-development rights on a potash project near Millstream. The company started drilling in February 1981. In addition to the basic 6¼ per cent royalty that New Brunswick will receive, BP agreed to pay the province about 20 per cent on the net cash profits accumulated in excess of a 15 per cent cash flow return on investment.

The New Brunswick Department of Natural Resources plans to offer for tender during 1981 a fourth area (near Dorchester) with geological potential for potash mineralization.

In Nova Scotia, a potash discovery in the Bras d'Or area of Cape Breton Island resulted in much activity. Currently, Chevron Canada Limited is drilling a complex potash-bearing structure and Noranda Exploration Company, Limited and Hallmark Mining Co. are also active in the area. Other companies recently acquired exploration concessions.

In Manitoba, the potash deposits which underlie eastern Saskatchewan extend up to 20 km east of the Saskatchewan-Manitoba border and are currently under renewed

TABLE 5. CANADA, POTASH SALES BY PRODUCT AND AREA, 1979 AND 1980

		Agricultural					Industrial			Total Sales
		Standard	Coarse	Granular	Soluble	Total	Standard	Soluble	Total	
		(tonnes K_2O equivalent)								
Alberta	1979	4 518	512	13 156	238	18 424	10 879	1 093	11 972	30 396
	1980	6 483	1 074	14 466	695	22 718	8 324	197	8 521	31 239
British Columbia	1979	425	3 968	6 941	-	11 334	676	80	756	12 090
	1980	350	1 997	7 115	24	9 486	659	-	659	10 145
Manitoba	1979	889	6 150	7 227	159	14 425	66	-	66	14 491
	1980	347	5 768	10 485	516	17 116	-	-	-	17 116
New Brunswick	1979	-	9 455	54	-	9 509	-	-	-	9 509
	1980		7 062	-	-	7 062	-	-	-	7 062
Northwest Territories	1979	-	-	-	-	-	-	-	-	-
	1980	-	-	-	-	-	-	-	-	-
Nova Scotia	1979	-	6 224	-	-	6 224	-	-	-	6 224
	1980	-	5 041	-	-	5 041	-	-	-	5 041
Ontario	1979	2 840	182 796	17 229	675	203 540	566	5 919	6 485	210 025
	1980	2 661	175 329	40 480	4 495	222 965	393	4 829	5 222	228 187
Prince Edward Island	1979	-	15 384	-	-	15 384	-	-	-	15 384
	1980	-	9 761	-	-	9 761	-	-	-	9 761
Quebec	1979	333	74 206	818	-	75 357	209	-	209	75 566
	1980	560	45 404	10 916	-	56 880	49	13	62	56 942
Saskatchewan	1979	1 820	998	1 300	554	4 672	322	290	612	5 284
	1980	1 786	829	2 579	3 099	8 293	3 140	766	3 906	12 199
Totals	1979	10 825	299 693	46 725	1 626	358 869	12 718	7 382	20 100	378 969
	1980	12 187	252 265	86 041	8 829	359 322	12 565	5 805	18 370	377 692

Source: Potash and Phosphate Institute.
- Nil.

exploration. IMCC has the main interests and the company will decide in 1981 whether to proceed with a production proposal.

MARKETING

Sales of Canadian potash in 1980 were 7 523 000 t K_2O equivalent, a 6.3 per cent increase over 1979. Offshore exports at 2 170 018 t were 17.6 per cent higher. Domestic agricultural sales in 1979 were 359 322 t in the form of muriate delivered by Canadian producers and 16 116 t as sulphate delivered by U.S. producers. Data published by Statistics Canada (Table 1) is inconsistent with producer reports. It is most probable that some of the amount listed as imports under potassium chloride was, in fact, potassium sulphate, and much of the remainder of potassium chloride was "mixed fertilisers".

Domestic non-agricultural potash sales in 1980 were 18 787 t, of which 18 370 t were delivered by Canadian producers. Canadian exports to the United States in 1980 were 4 355 895 t K_2O, a 7.5 per cent decrease from the previous year. Poor weather conditions and the continuation of the grain sales embargo to the U.S.S.R. were the main reasons for the decline.

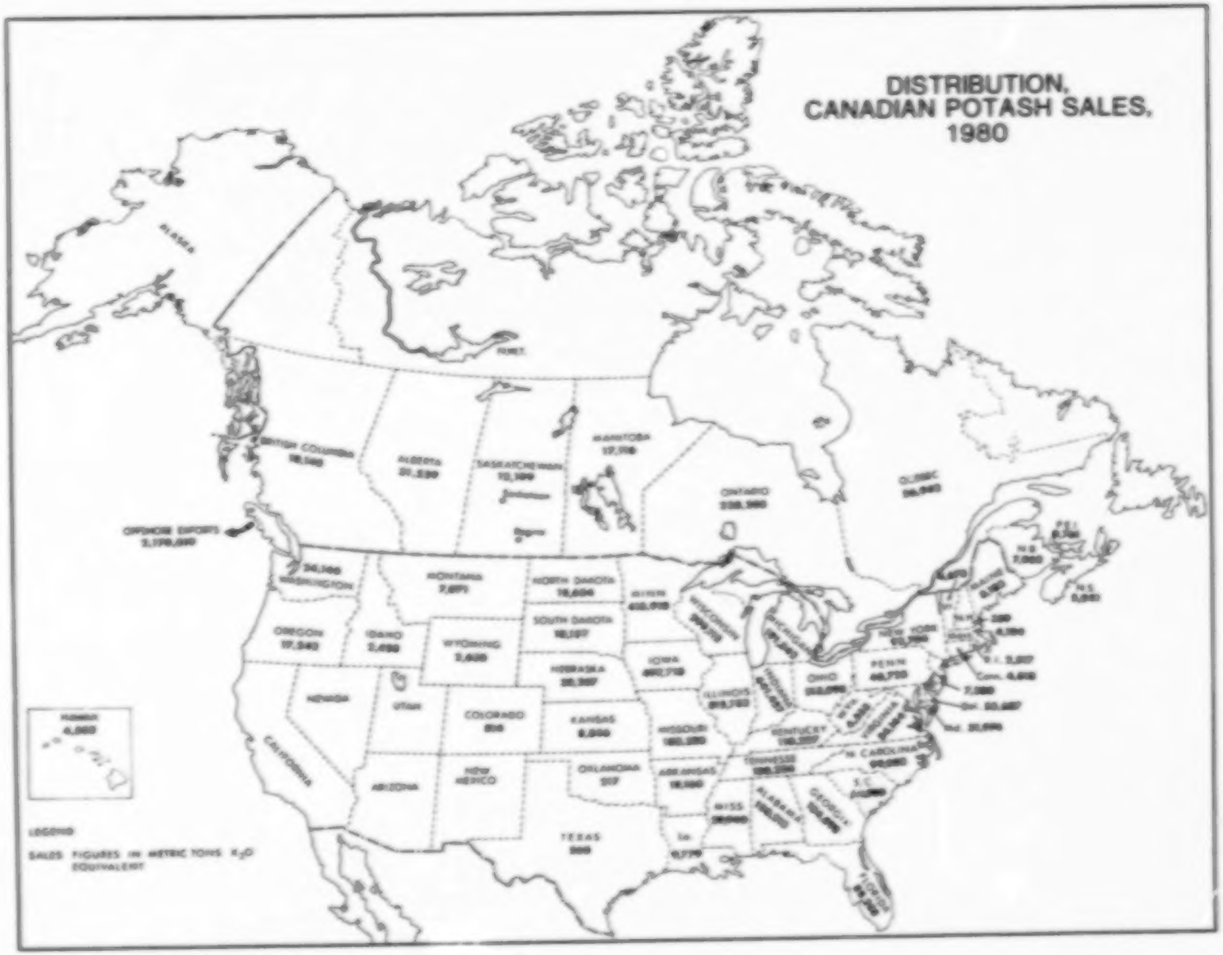
Canpotex Limited represents all the Canadian potash producers except PCA and PPG for offshore sales. Canpotex potash exports were up 22 per cent in 1980 after a very strong performance in 1978 and 1979. There are indications however that 1981 will be a year with lower sales. Canpotex sells to offshore markets only, which are generally defined as all markets excluding Canada and the United States. In 1980 Canpotex sold 3.3 million t of product (in various grades of muriate of potash) out of total offshore exports of 3.6 million t (91.5 per cent). During 1980, Canpotex's sales were at record levels to Brazil, India, China, Malaysia, Indonesia, Taiwan, Mexico, the Philippines, Chile, Swaziland and Nicaragua. Generally, offshore markets in 1980 experienced tight supply and only the ability of Canadian exporters to produce and ship record quantities of potash resulted in orderly markets. After failing to meet contracted volumes in 1979, the U.S.S.R. increased exports in 1980 by some 700 000 t, with 60 per cent of this increase destined for east European markets.

Transport of "offshore" potash to Vancouver is carried out by 85-car unit trains at a cost of $22-24 per t of product (KCl). Approximately 1,500 rail cars were utilised in this service by the end of 1980. Turn-around time is about 12 days. Some back-haul, particularly phosphate rock into the Edmonton area, is also available. A key CNR bridge across Vancouver Narrows was hit by a ship and closed from October 1979 to March 1980. Potash unit trains were uncoupled and cars were put on barges to circumvent the closed bridge. Overseas shipments were reduced to about two-thirds of anticipated levels.

For the second consecutive year there was a large increase in shipments of potash through Thunder Bay, from 443 000 t (KCl) in 1979 to 808 000 t in 1980. More than half of the shipments were to the United States and the remainder to eastern Canada, mainly through Port Stanley and Montreal. Canpotex sells about 80 per cent fob Vancouver and 40 per cent c & f customer's port. Most customers buy bulk product but a warehouse is maintained in Singapore to supply bagged product to southeast Asia. Canpotex Shipping Services Limited charters its own ships for some overseas contracts. Since 1979 Canpotex has been part of a ship-chartering group that rationalises some fertiliser and other commodity shipments, operating under the name of Fertivoy.

In December 1980 a consortium of companies including Canpotex purchased the Neptune Bulk Terminals Ltd. in Vancouver. The terminal will operate under the name Neptune Bulk Terminals (Canada) Ltd. Canpotex Bulk Terminals Limited was formed as the investment holder of potash producers in Neptune. The major shareholder is PCS. The terminal is capable of handling 60 000 t vessels and can load at a rate of 2 700 t per hour. An 85-car potash unit-train can be unloaded in six hours.

Potash delivery systems to the United States were greatly improved during 1980. PCS implemented a unit train system early in 1980 to increase delivery capacity and improve customer service. Under this system, product is moved to high-capacity terminals, or potash centres, in the U.S. by trains which operate on a continuous cycle from Saskatchewan mines. The trains complete a round trip to terminals in Illinois and Iowa in less than eight days, compared with 30 to 40 days in regular, "single-car" delivery. Once in the potash centres, product is available to customers for immediate delivery by truck. The unit train offers improved service to consumers in the vicinity of the potash centres, improved car supply,



DISTRIBUTION, CANADIAN POTASH SALES, 1980

ALASKA
N.W.T.
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUEBEC
P.E.I.
N.B.
N.S.
OFFSHORE EXPORTS
WASHINGTON
OREGON
17,340
IDAHO
MONTANA
WYOMING
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
MINN
WISCONSIN
MICHIGAN
IOWA
ILLINOIS
INDIANA
OHIO
PENN
NEW YORK
MAINE
R.I.
Conn.
Del.
Md.
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
KENTUCKY
CALIFORNIA
ARIZONA
NEW MEXICO
OKLAHOMA
217
ARKANSAS
TENNESSEE
N. CAROLINA
S.C.
TEXAS
MISS
ALABAMA
GEORGIA
La.
FLORIDA
HAWAII
LEGEND
SALES FIGURES IN METRIC TONS K_2O EQUIVALENT

TABLE 6. PROVINCE OF SASKATCHEWAN: NON-INCOME-TAX REVENUE FROM THE POTASH INDUSTRY, 1970-80

Calendar Year	Non-Income-Tax Revenue ($ Millions)[1]	Non-Income-Tax Revenue as a Per Cent	Non-Income-Tax Revenue ($/t$K_2O$ of Production)[1]	Real Non-Income-Tax Revenue ($/t$K_2O$ of Production)[2]
1970	2.7	2.48	0.84	1.15
1971	2.8	1.92	0.78	1.04
1972	5.6	3.84	1.42	1.79
1973	8.4	4.30	1.97	2.27
1974	34.6	11.10	6.29	6.29
1975	97.9	28.10	18.02	16.28
1976	82.8	23.10	16.58	13.66
1977	114.4	28.74	18.78	14.47
1978	126.7	25.45	20.72	14.96
1979	152.4	20.73	21.54	15.62
1980	228.7	23.19	30.40	..

Source: D.L. Anderson, **Mineral Taxation in Industry/Government Conflict, 1981** (amended).

[1] Current year dollars. [2] End-1974 dollars, based on the gross national expenditure implicit price index. For details, see Statistics Canada, National Income and Expenditure Accounts, catalogue no. 13-001.

.. Not available.

and a reduced "peaking" problem for the railroads in the spring and fall fertiliser seasons.

PRICES

Potash prices during 1980 were very firm, particularly on the export markets. The Canadian producers averaged a return of about $Cdn 135 per t of K_2O compared to $Cdn 95 during 1979. In the United States the average price fob U.S. mine for standard and (granular) potash were $US 120.30 (132.48) for the first half of 1980 and $US 133.82 (145.10) for the second half of 1980. United States realised prices are usually $3 to $6 a t higher than Canadian prices.

INTERNATIONAL

The entire world output of potash is essentially produced by 10 countries, of which 6, the U.S.S.R., Canada, East Germany, West Germany, the United States and France, account for 95 per cent of the total. Potash demand in 1980 was estimated at 27.0 million t about equal to the estimated production level. Demand is calculated as estimated consumption plus 6 per cent for distribution, processing and other losses.

Production in United States has essentially been unchanged for the past four years at 2.2 million t. Seven companies producing from underground mines in New Mexico accounted for 85 per cent of U.S. production, mining 18 million t of crude ore grading an average of 13.6 per cent K_2O (13.8 per cent K_2O in 1979). AMAX Chemical Corporation started a 15 per cent refinery capacity increase which should be completed in 1983.

It is estimated that potash production in the U.S.S.R. is back to normal at about 8.0 million t. K_2O after recovering from 1979, a year plagued with transportation problems and production shutdowns. There were unconfirmed rumours of a flood in one mine. In 1979 the U.S.S.R. produced only 6.6 million t. In November 1980 a fertiliser ministry was separated from the chemical industry to improve prospects for a very ambitious expansion plan which at one time included a 50 per cent increase in potash capacity between 1980 and 1985.

Expansion of potash mining in Israel is making good progress and the construction of a new mine in Jordan is on schedule. A contract to open a small underground mine in Brazil by 1983 has also been finalised. High

TABLE 7. CANADA, POTASH MINES - CAPACITY PROJECTIONS

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Remarks
	(000 tonnes)											
PCS												
Allen (60%)	490	490	490	490	490	655	655	655	655	655	655	Not a firm commitment.
Bredenbury	-	-	-	-	-	-	655	1 310	1 960	1 960	1 960	Mid-1986, earliest target.
Cory	830	830	830	830	830	950	1 090	1 090	1 090	1 090	1 090	Not a firm commitment.
Esterhazy (25% of IMC)	585	585	585	585	585	585	965	965	965	965	965	Not a firm commitment.
Lanigan	565	685	830	830	1 285	1 740	1 740	1 740	1 740	1 740	1 740	Phase II completed by end of 1983.
Rocanville	725	750	1 090	1 090	1 090	1 090	1 090	1 090	1 090	1 090	1 090	At full capacity by end of 1981.
Sub-total	3 175	3 360	3 685	3 825	4 280	5 030	6 175	6 830	7 480	7 480	7 480	
NORANDA METAL	815	815	815	815	815	815	815	815	815	815	815	
COMINCO	565	565	600	655	655	655	655	655	655	655	655	At full capacity, by mid-1982.
IMCC	1 750	1 750	1 750	1 750	1 750	1 750	2 110	2 110	2 110	2 110	2 110	Conjectural - not a firm commitment.
PPG (Kalium)	865	865	1 055	1 055	1 055	1 055	1 055	1 055	1 055	1 055	1 055	Expansion completed by end of 1981.
PCA	440	440	440	635	635	635	635	635	635	635	635	Expansion completed by end of 1982.
TEXASGULF INC. (Allen 40%)	325	325	325	325	325	435	435	435	435	435	435	Not a firm commitment (expansion could be higher).
Sub-total	4 720	4 720	4 985	5 235	5 225	5 335	5 705	5 705	5 705	5 705	5 705	
Total Saskatchewan	7 895	8 080	8 680	9 060	9 505	10 365	11 880	12 535	13 185	13 185	13 185	
DENISON, N.B.	-	-	-	-	100	400	765	765	765	765	765	Expansion after 1986 possible.
PCA, N.B.	-	-	-	200	400	565	540	540	540	540	540	Expansion after 1985 possible.
IMC, MAN.	-	-	-	-	-	-	-	565	1 090	1 090	1 090	Conjectural start-up between 1986 and 1988.
Unspecified	-	-	-	-	-	-	-	-	-	500	1 000	Further conjectural expansions, mostly in Maritimes.
Total Canada	7 895	8 080	8 680	9 260	10 005	11 330	13 190	14 390	15 585	16 085	16 585	

TABLE 8. WORLD POTASH CAPACITY 1978-90

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	(000 tonnes K_2O equivalent)												
North America													
Canada	7 575	7 800	7 895	8 060	8 680	9 260	10 005	11 310	13 190	13 945	15 040	15 835	16 085
United States	2 570	2 570	2 500	2 575	2 575	2 575	2 650	2 550	2 400	2 300	2 200	2 100	2 000
Total	10 145	10 370	10 395	10 635	11 255	11 835	12 655	13 860	15 590	16 245	17 240	17 935	18 085
Western Europe													
France	2 200	2 200	2 200	2 100	2 000	2 000	2 000	2 000	2 000	1 800	1 700	1 500	1 300
Germany, Fed. Rep.	2 920	2 920	2 920	3 000	3 000	3 000	3 100	3 100	3 100	3 100	3 100	3 100	3 100
Italy	235	235	250	260	270	270	270	270	270	270	280	300	300
Spain	780	780	780	780	800	800	800	800	800	800	800	800	1 000
United Kingdom	600	600	360	300	300	300	300	300	300	300	300	300	300
Total	6 735	6 735	6 510	6 440	6 370	6 370	6 470	6 470	6 470	6 270	6 180	6 000	6 000
Eastern Europe													
Germany, Dem. Rep.	3 200	3 400	3 400	3 500	3 600	3 800	3 800	3 800	3 800	3 800	3 800	3 800	3 800
U.S.S.R.	9 650	10 000	10 800	11 600	12 400	13 200	14 000	15 000	15 500	15 800	16 000	16 400	17 000
Total	12 850	13 400	14 200	15 100	16 000	17 000	17 800	18 800	19 300	19 600	19 800	20 200	20 800
Asia													
Israel	750	750	750	750	1 000	1 000	1 000	1 260	1 260	1 260	1 260	1 260	1 260
Jordan	-	-	-	-	-	200	500	720	720	720	720	720	720
China, People's Rep.	50	50	50	50	50	50	50	50	50	50	50	50	50
Thailand-Laos	-	-	-	-	-	-	-	-	-	-	-	-	100
Total	800	800	800	800	1 050	1 250	1 550	2 030	2 030	2 030	2 030	2 030	2 130
Others													
Brazil	-	-	-	-	-	100	200	250	250	250	250	250	400
Chile	25	25	30	30	30	30	30	30	30	30	30	30	30
Peru	-	-	-	-	-	-	-	-	50	100	100	100	100
Total	25	25	30	30	30	130	230	280	330	380	380	380	530
World Total	30 555	31 330	31 845	33 005	34 705	36 585	38 625	41 440	43 720	44 525	45 630	46 545	47 545

Note: The inclusion of Thailand-Laos is indicative of their potential as new producers by late 1980s or early 1990s and not a specific target date for production.

Source: Energy, Mines and Resources Canada.

production costs and other technical problems are still experienced by mines in Spain and the United Kingdom.

World capacity expansion to 1990 is almost entirely predicated on events in Canada and the U.S.S.R. as shown in Table 8. There appears to be no problems for the expansion of the Canadian capacity.

OUTLOOK

After two excellent years in 1979 and 1980 when production and world trade reached record levels there are signs of a pause in demand for 1981 and 1982. This is mainly due to adverse worldwide economic conditions rather than a planned decrease in potash utilization. Eventually, demand will have to approach the projected utilization levels that follow a trend line of about 4 per cent in annual growth. Any serious deviation from this utilization of potash in the agricultural sector could lead to serious declines in crop production and food supply.

Known and forecast mine capacity increases for the 1980s will meet normal demand levels unless some significant delays in expansions take place, particularly in the U.S.S.R. and Canada.

Rare Earths

D.A. CRANSTONE

The rare earth elements, sometimes called the lanthanons or lanthanides, are a group of 15 chemically similar metals having atomic numbers 57 to 71 in Group III of the periodic table of elements. Scandium and yttrium are similar to the rare earth elements in many respects and are usually classed with them.

These elements are neither rare nor earths. By comparison, cerium is more abundant than tin or cobalt and almost three times as abundant as lead. Thulium, less common than all other rare earths except promethium, is more abundant than silver, gold and platinum combined. The metals were originally classified "rare" because they are seldom concentrated in nature like most other elements and their widespread occurrence in the earth's crust was recognized only in recent times. The term "earth" is derived from earlier terminology when insoluble oxides, the common compounds of rare earths, were simply referred to as earths.

Lanthanon-bearing minerals contain all members of the rare earth elements, but either the light (cerium) group or the heavy (yttrium) group predominates in each mineral. The rare earth metals are typically associated with alkalic intrusive igneous rocks and also occur as secondary concentrations in placer, beach sand and phosphatic sedimentary deposits. Commercial production has been derived from carbonatite occurrences, placer and beach sand deposits, uranium ores, and phosphatic rocks.

Monazite is a rare earth phosphate that contains nearly 70 per cent rare earth oxides (REO) and about 1.5 per cent yttrium oxide. Modern placer deposits in the form of heavy mineral sands are the major source of monazite, where it is usually exploited as a byproduct of rutile, ilmenite and zircon mining operations. Only in a few cases have primary deposits been exploited for monazite, a deposit in South Africa having been the world's major source of monazite from 1953 to 1963. Bastnaesite is a fluorcarbonate of the cerium subgroups. It contains about 75 per cent REO and only about 0.05 per cent yttrium, and occurs in economic quantities in vein deposits, contact metamorphic zones and pegmatites and other igneous rocks. Xenotime, the yttrium phosphate isomorph of monazite is the main source of yttrium and the "heavy" rare earth elements. The relative abundance of the various rare earths in the ores presently being mined is not directly related to the market demand for the individual products. As a result, some rare earth products are readily available at low prices while others, particularly high-purity metal and compounds, are considerably more expensive. Research continues to explore the properties of the rare earth metals to identify potential new markets but, for some, no significant use has yet been found. Development has proceeded, first to find markets for those compounds that are available, and second to find and develop sources of supply to meet changing industrial requirements.

New uses have developed steadily in recent years. Beginning with the traditional cigarette lighter flints and carbon-arc uses, rare earth elements have now found application in glass polishing, television tube phosphors, nodular iron, high-strength low-alloy steel and high-strength magnet applications. Rare earth elements in zeolite catalysts for petroleum refining was the major use for rare earths for the second half of the 1960s and most of the 1970s, but by 1979 more rare earth oxides were being consumed in the metallurgical industry than in any other industry. The latest uses of rare earth products are at the forefront of technological development, in refractory ceramics, in the latest developments in fluorescent lighting, in data storage, in the energy field, in catalysts used to reduce nitrogen oxides back to nitrogen and in hydrogen sponge alloys. Distribution of world consumption of rare earth oxides between the metallurgical, petroleum refining and glass industries in 1978 has been estimated at 35 per cent, 33 per cent, and 26 per cent, respectively. More recent estimates are not available.

New markets for specific members of the rare earth group have resulted in increased production of all of the rare earth metals because of their natural association in ores. Similarly, production costs for some rare earth members, produced as byproducts of the refining process, have diminished. Availability and declining costs have been important factors in the development of new uses. There is growing optimism that the rare earth metals industry will expand at a steady rate now that industrial uses are becoming more diverse. The energy shortage should have an important effect on rare earth market growth in the 1980s, as the use of rare earth phosphors in high performance fluorescent tubes and of lanthanum and mischmetal in hydrogen storage systems should increase significantly.

CANADIAN INDUSTRY

From 1966 to 1970, uranium mines in the Elliot Lake district of Ontario were the world's major source of yttrium concentrate. All rare earths except promethium have been detected in these ores. The Elliot Lake ores contain about 0.11 per cent uranium oxide (U_3O_8), 0.028 per cent thorium oxide (ThO_2) and 0.057 per cent rare earth oxides.

Canadian production of rare earths since 1967 has undergone drastic adjustments; yttrium concentrate suppliers reduced shipments each successive year until 1971, when deliveries stopped. Shipments of yttrium concentrate from one Canadian producer, Denison Mines Limited, were resumed in 1973 and continued to the end of 1977. There has been no production of rare earths in Canada since then.

Denison ceased production of yttrium concentrate in 1978 because yttrium recovery had become uneconomic, owing to higher costs of the chemical reagents used in the yttrium circuit. Denison had been shipping its yttrium concentrate to Molycorp, Inc. and had previously shipped yttrium concentrate to Michigan Chemical Corporation, but shipments to the latter company were terminated in mid-1970 when Michigan Chemical experienced difficulty in marketing the product.

During 1966 and 1967 Rio Algom Mines Limited recovered thorium and rare earth concentrate at its Nordic mill, but did not

TABLE 1. RARE EARTH ELEMENTS

Atomic No.	Name	Symbol	Abundance in Igneous Rocks
	(Light rare earths)		(parts per million)
21	Scandium	Sc	5.0
57	Lanthanum	La	18.3
58	Cerium	Ce	46.0
59	Praseodymium	Pr	5.5
60	Neodymium	Nd	23.8
61	Promethium	Pm	(Not measurable)
62	Samarium	Sm	6.5
63	Europium	Eu	1.1
64	Gadolinium	Gd	6.3
	(Heavy rare earths)		
39	Yttrium	Y	28.0
65	Terbium	Tb	0.9
66	Dysprosium	Dy	4.5
67	Holmium	Ho	1.1
68	Erbium	Er	2.5
69	Thulium	Tm	0.2
70	Ytterbium	Yb	2.6
71	Lutetium	Lu	0.7
	Total		153.0

resume production when the milling of uranium ores was subsequently transferred to the Quirke mill.

Rare earth elements, primarily the light element group, are associated with apatite in the Nemegos No. 6 magnetite deposit, which is located in the Chapleau area of Ontario. Multi-Minerals Limited is seeking to develop the deposit, and was trying at last report in 1975 to determine the feasibility of promoting an integrated complex that would produce pig iron, phosphoric acid and rare earth products.

In addition to the large reserves in Elliot Lake uranium ores, rare earths are also associated with uranium deposits at Agnew Lake, 65 kilometres (km) east of Elliot Lake (where the REO content is about twice that of Elliot Lake ores), and in the Bancroft area of Ontario.

Highwood Resources Ltd. reported that its Thor property, 104 km southeast of Yellowknife in the Northwest Territories, contains a large deposit of tantalum and columbium-bearing material, together with the rare earths and yttrium. The property was optioned to Placer Development Limited in March 1980 and is being diamond drilled by Placer.

TABLE 2. CANADIAN SHIPMENTS OF RARE EARTH CONCENTRATES

	Y_2O_3 Concentrates (kilograms)	Values ($)
1980	-	-
1979	-	-
1978	-	-
1977[1]	30 400	..
1976[1]	26 308	..
1975[1]	34 927	..
1974	39 366	..
1973	..	..
1972	-	-
1971	..	..
1970	33 112	657,000
1969	38 756	671,500
1968	51 406	936,067
1967	78 268	1 594,298
1966	9 400	130,223

Sources: Statistics Canada; [1] Annual Reports, Denison Mines Limited.

.. Not available; - Nil.

Significant quantities of the rare earths are found in a number of Canadian pyrochlore-bearing carbonatite deposits such as the Niobec Inc. mine near St. Honoré, Quebec and in the deposits on the Manitou Islands, Lake Nipissing, Ontario.

Phosphorite formations in western Canada contain small quantities of rare earths, as do Florida phosphates imported into Canada for the production of phosphoric acid. Other potential sources include apatite rich carbonatites in Ontario and Quebec.

Shipments of rare earth concentrates since 1966 are summarized in Table 2. Statistics for 1971 and 1973 have been withheld to avoid disclosing company confidential data.

The Denison yttrium concentrates contain all of the rare earth elements. An analysis published in the 1980 edition of Roskill Information Services Ltd.'s "The Economics of Rare Earths and Yttrium" gives the following analysis in terms of oxides: lanthanum (La_2O_3) 0.8%; cerium (CeO_2) 3.7%; praseodymium (Pr_6O_{11}) 1.0%; neodymium (Nd_2O_3) 4.1%; samarium (Sm_2O_3) 4.5%; europium (Eu_2O_3) 0.2%; gadolinium (Gd_2O_3) 8.5%; terbium (Tb_4O_7) 1.2%; dysprosium (Dy_2O_3) 11.2%; holmium (Ho_2O_3) 2.6%; erbium (Er_2O_3) 5.5%; thulium (Tm_2O_3) 0.9%; ytterbium (Yb_2O_3) 4.0%; lutetium (Lu_2O_3) 0.4%; and yttrium (Y_2O_3) 51.4%; total 100%.

WORLD INDUSTRY

The minerals monazite and bastnaesite are the main source of the cerium group of rare earths. These are processed to recover mixed rare earths for low-value products such as mischmetal or further processed at much higher cost to separate individual rare earth metals.

Monazite recovery is a byproduct of mining beach sands for rutile, zircon and ilmenite, and from tin placers. Australia, India, Brazil, Malaysia, the United States and South Africa are the principal producers. In the United States, monazite is recovered from beach sands in Georgia and Florida.

The Molycorp mine at Mountain Pass, California, operated by Molycorp, Inc., a subsidiary of Union Oil Company of California, is the main source of concentrates for cerium-group rare earths; unlike monazite, bastnaesite concentrates from this unusual carbonatite deposit do not contain thorium. The ore, mined in a small, low-cost open-pit, grades about 7 to 10 per cent rare earth oxides. The rare earth distribution as oxides is: cerium 50.0%; lanthanum 34.0%; neodymium 11.0%; praseodymium 4.0%; samarium 0.5%; gadolinium 0.2%; europium 0.1%; and yttrium group 0.2%. The adjacent mill produces a flotation concentrate grading 55 to 60 per cent rare earth oxide, a leached concentrate grading about 70 per cent, a calcine grading 90 per cent and seven modified concentrates. A chemical and solvent extraction plant makes intermediate rare earth products and separates a number of rare earths, including europium. Mining and milling capacity is about 41 000 tonnes per year (tpy) of rare earth oxides in bastnaesite concentrates. The chemical plant has a production capacity of about 16 000 tpy of rare earth oxides. Further processing is carried out at Louviers, Colorado; York, Pennsylvania; and Washington, Pennsylvania. The balance of the bastnaesite concentrates are sold as concentrates.

With the takeover of Molycorp by Union Oil Company of California in 1977 production statistics for the Molycorp operation are no longer available in terms of production of [illegible] but only in terms of tonnages of rare earth concentrates. Production of rare earth concentrates in 1980 was 15 986 t. In the rare earths review for 1979, an error was made in reporting Molycorp rare earths production for 1979, 1978 and 1977. The correct quantities should have been 16 515, 14 148 and 15 359 t respectively.

Early in 1980, Molycorp started construction called for by its multi-million dollar program to increase production of separated rare earths. The largest part of this program, at Mountain Pass, California, involves installation of six new solvent extraction circuits for production of additional samarium and gadolinium as well as cerium, lanthanum, neodymium and praseodymium. These are scheduled for completion in 1981. Molycorp also completed a samarium metal production plant at Washington, Pennsylvania, at the end of 1980, and plans to start new projects in 1981 for increased production of yttrium and rare earth chloride.

In Canada, Sherritt Gordon Mines Limited reported that it had improved its production methods for cobalt-samarium alloy powder used in the manufacture of high-strength permanent magnets and that the company expected increased sales volume in 1981. Sherritt's production facility for cobalt-samarium alloy powder was put into operation at Fort Saskatchewan in 1979. Earlier, the company had undertaken a research program to further develop and improve the cobalt-rare earth powder technology it had purchased from Canadian General Electric Company Limited. Continuing operating losses at Sherritt's 60 per cent owned Spectra-Flux, Inc. in California, purchased by Sherritt in April 1979, led to a decision to close this small producer of cobalt-samarium magnets.

Rhone Poulenc Industries, of France, also a major producer of rare earth metals and chemicals, is expanding production facilities at its La Rochelle plant in France and is also building a new rare earth separation and finishing plant at Freeport, Texas, where work is scheduled for completion in June 1981. The new plant, which will process monazite, will incorporate technologically advanced, proven processing techniques for the separation of high purity rare earth products, will employ about 100 people and produce about 4 000 tpy of rare earths.

Allied Eneabba Pty. Ltd., an affiliate of E.I. Du Pont de Nemours & Co., Inc. of the United States, completed an improvement and expansion program at its dry-separation plant at Geraldton in Western Australia. Construction of a new zircon circuit to produce up to 10 000 tpy of a very coarse-grained zircon product is in progress, with the product aimed at the refractory and foundry industries. An extension of the monazite processing facilities is to increase capacity by 30 per cent, and to increase monazite storage capacity to accommodate increased production.

Indian Rare Earths Limited is developing a new mineral sands complex in the State of Orissa, with completion scheduled for mid-1981. Production capacity will be some 4 000 tpy of monazite. There are also plans to set up a monazite processing plant at Orissa. Because of the thorium content of monazite, India requires that it be processed to rare earth compounds domestically.

During 1980, new plants to convert monazite to rare earth chloride were also under construction in Malaysia and England, and a plant expansion project was in progress in France.

CONSUMPTION AND USES

World consumption of the rare earths in 1980 increased slightly over that of 1979. Although samarium was in tight supply in 1978 and 1979, shipments were lower in 1980, and increased supply was available from Molycorp's expansion at Washington, Pennsylvania. The samarium market is expected to continue to grow.

There is considerable interest in the development of less costly rare earth metal mixtures as substitutes for samarium in magnets. These "adjusted mischmetals" are in plentiful supply but potential users must first determine the alloy compositions most suitable for mass production of magnets.

A recent development has been the demand for rare earth chemicals by the automotive industry. Yttrium-stabilized zirconia exhaust gas sensors for carburetor control became standard for most U.S. produced automobiles. Also, rare earth stabilisation of the gamma-alumina coatings that carry the active catalysts, such as the platinum metals for three way exhaust purification systems, is in use in many 1981 automobiles.

Some 65 per cent of the western world's consumption of rare earths occurs in the United States, about 10 per cent in Japan, and about 25 per cent in the rest of the western world, mostly in Europe. The principal consuming countries other than the United States import all or nearly all of their raw material requirements either in the form of bastnaesite from Molycorp, Inc., monazite concentrates from Australia, or rare earth chlorides from India and Brazil. Because the U.S. production of monazite by the two companies in Florida is small, considerable quantities of monazite are imported into that country. Japan imports most of its raw material requirements in the form of bastnaesite and rare earth chlorides. France, the world's third largest rare earth processing country, imports most of its raw material in the form of monazite. Other European countries that are important processors of the rare earths are West Germany, the United Kingdom and Austria, with these countries using both monazite and bastnaesite as raw materials.

Mischmetal is a suitable nodulising alloy that promotes ductility in cast iron by neutralising the harmful effects of trace elements that inhibit the formation of nodular graphite. The ductile iron industry has realised significant cost savings through the substitution of mischmetal for more expensive additives.

Mischmetal, the primary commercial form of mixed rare earth metals, is prepared by the electrolysis of fused rare earth chloride mixtures. Mischmetal contains 94 to 99 per cent rare earth metals plus traces of calcium, carbon, aluminum, silicon and iron. A typical composition is 52 per cent cerium, 18 per cent neodymium, 5 per cent praseodymium, 1 per cent samarium and 24 per cent other rare earths including lanthanum. Some grades are nearly free of cerium. Ferrocerium is an alloy of mischmetal and iron.

In recent years the practice of adding some 1.5 kg of mischmetal or of rare earth silicides to each tonne of high-strength low-alloy (HSLA) steels has become general, to counter the deleterious effects of sulphur. The conventional method of treating undesirable sulphur is to combine it with magnesium; but magnesium sulphide elongates when rolled so that the resulting steel is weaker in the transverse direction. The addition of rare earths results in a HSLA steel that is nearly equally strong in the transverse and longitudinal directions. HSLA steels are being used increasingly in gas and oil pipelines, automobiles, trucks, trains, ships and construction equipment. Mischmetal has a stable market in the production of lighter flints, but the lighter flint market is becoming relatively less important as mischmetal applications grow in the iron and steel metallurgical fields.

The other major use of the rare earth group is for catalysts in the cracking operation of petroleum refining. Although naturally mixed elements were originally used in catalysts, the trend has been to the use of chloride mixtures of lanthanum, neodymium and praseodymium. Although unit consumption in this field is up, it has been of declining importance in recent years, relative to other uses. Palladium is a substitute for the rare earth elements as a catalyst in petroleum-refining. In addition to petroleum cracking catalysts, new rare earth catalysts have recently been developed for production of styrene plastic.

The third most important market for rare earth metals, in terms of volume, is the glass polishing industry. Commercial-grade cerium and mixed rare earth oxides are used extensively in optical, mirror and plate glass polishing. Usage for plate glass polishing has been reduced since the introduction of the Pilkington float glass process, but there is no comparable substitute for rare earth oxide compounds in high-quality optical polishing.

The glass industry employs rare earth additives for their many unique characteristics. Cerium oxide, in small quantities, is an effective glass decolouriser. Owing to their ability to absorb ultraviolet light, cerium and neodymium oxides are used in the manufacture of transparent bottles to inhibit food spoilage, and in welders' goggles, sunglasses and optical filters. For glass colouring, praseodymium imparts a yellow-green colour, neodymium a lilac, europium an orange-red, and erbium a pink colour. Lanthanum is a major component of optical glass, and cerium glass is used for windows in atomic reactors.

Rare earth oxides and fluorides are used in signficant quantities in carbon-arc lamps where a high intensity white light is desirable.

A new type of fluorescent lamp is now on the market that emphasizes three narrow spectral bands around the blue-violet, green and orange-red wavelengths to produce a synthesized white light. This new light has a greater "perceived brightness" than even natural sunlight and permits a reduction in the number of lighting units in buildings. The new light uses two rare earth phosphors that contain europium.

High-value applications are in the electronics field, where rare earth oxides are used as phosphors in colour television tubes, in temperature-compensating capacitors and in associated circuit components. Although the volume of europium and yttrium oxides used in colour television phosphors is comparatively small, the value is disproportionately large because of the high degree of purity required in this application. Minor quantities of rare earth elements are used in laser materials, "atomic fire extinguishers" and nuclear reactor absorption and shielding materials (owing to their high neutron absorbing capabilities), magnesium and aluminum alloys, brazing alloys, low-corrosion alloys, gemstones, self-cleaning oven catalysts, ceramic and porcelain stains and microwave controls.

Rare earth-cobalt permanent (RE) magnets are an important and growing market. Samarium-cobalt permanent magnets that have many times the strength of any conventional permanent magnet are now in use. These magnets are usually fabricated by powder metallurgical methods that facilitate the procedure for inducing a high magnetic flux. High-strength permanent magnets are used in special applications such as aerospace equipment, where the greater cost can be justified in terms of better performance. Considering the many developments that have occurred within the few years since RE magnets were first discovered, a strong growth rate seems likely in the use of these magnets for the next several years in electric motors, generators, meters, speakers, frictionless bearings, self-holding magnetic earrings and other jewellery. United States automobile manufacturers are studying the use of mischmetal-cobalt magnets in starter motors, fuel gauges, electronic ignition systems, windshield wipers, window and seat drives, and in new developments such as continuous monitoring of tire pressure. Full realization of these potential uses will require further cost and weight reduction, assured availability of cobalt and utilisation of rare earth metals other than samarium.

Rare earth metal catalysts have been identified as possible inexpensive alternatives to platinoid catalysts in automobile exhaust converters. Rare earth-based converters have shown promise in reducing carbon monoxide and nitrogen oxide emissions but more research is necessary. Initially, the automotive industry opted for platinum-based systems to meet emission control standards set for United States vehicles in 1975.

Research on rare earth metal uses has taken many directions and some very promising developments have resulted. "Hydrogen sponge" alloys have been developed that consist of nickel, and in some cases manganese, in combination with rare earth metals. These alloys can absorb up to 400 times their own volume of hydrogen gas. One cubic foot of these alloys can hold enough hydrogen to generate over 4 kilowatt-hours of heat energy. The ease with which the absorption process can be reversed by a relatively small change in temperature or pressure, the selectivity of the process to hydrogen gas, and the convenient temperature and pressure ranges over which it can occur, are keys to its usefulness. Potential applications are in solar heating, nonpolluting engines, heat sinks, gas purification and compression, and auxiliary power generation.

The development of magnetic bubble memory films for data storage and processing promises to become a major new application for rare earth materials, especially for gadolinium. Gadolinium-gallium garnet (GGG) has been found to be suitable for the production of precision wafers for these memory films. This new storage medium permits faster information handling with fewer moving parts, lower energy use and greater storage capacity. It also decreases vulnerability to the effects of power loss. GGG bubble memory storage capacity is claimed already to be competitive with other storage media presently in use, in terms of cost per bit of information.

Yttrium is receiving attention from researchers for use in refractory ceramics for use in gas turbines, combustion chambers, nuclear reactors and heat exchangers.

WORLD PRODUCTION

Australia and the United States together are estimated to have produced about 31 000 t (about 75 per cent of the world's production) of rare earth minerals in 1978. Brazil, India, Malaysia and the U.S.S.R. produced between 2 000 and 3 000 t each (most of the remainder of the world's production). Minor production came from Thailand, Zaire, Nigeria and Sri Lanka. Indonesia and North Korea may produce monazite but their output, if any, is not reported. Comparable world production figures for 1979 or 1980 are not available.

WORLD RESERVES

The Mountain Pass deposit of Molycorp contains an estimated 4.5 million t of REO, probably 80 to 90 per cent of the U.S. reserves and a large part of world reserves. The latter are estimated by the United States Bureau of Mines (USBM) to contain about 7 million t of REO and 35 million t of yttrium. Some 18 million t of the world's yttrium reserves are in India, and 3.2 million t are in the United States. Additional resources of REO and yttrium exist in the world, so that annual world demand for these elements represents only a tiny fraction of known reserves and additional resources. Although not included in reserve figures published by the USBM, China is believed to have the world's largest reserves of rare earths.

PRICES

The December 1980 issue of **Industrial Minerals** quotes the following prices for concentrates of rare earth minerals:

Bastnaesite concentrate 70% leached, per lb REO	$US 1.00
Monasite, minimum 55% REO, long ton, fob Australia	$A 350.00-400.00
Xenotime, Malayan, minimum 25%, per lb Y_2O_3, cif	$US 2.00-3.00

REO Rare earth oxides; fob Free on board; cif Cost, insurance and freight.

Prices for rare earth oxides, as quoted in the December 31, 1980 issue of **American Metal Market**, were:

Rare earth oxides, U.S. dollars per lb, one-lb lots

		($US)
Cerium	99.9%	8.00
Europium	99.99%	900.00
Gadolinium	99.9%	55.00
Lanthanum	99.99%	7.00
Neodymium	99.9%	38.00
Praseodymium	95%	16.50
Samarium	99.9%	35.00
Yttrium	99.99%	42.00

At the end of 1980 prices of rare earth metals, 99 per cent minimum purity, in U.S. dollars per pound for minimum lots of 500 to 2,000 pounds, depending on the metal, were:

	($US)
Cerium	26.00
Lanthanum	30.00
Samarium	65.00
Yttrium	165.00
Mischmetal	5.50

Salt

G.S. BARRY

Although many mineral commodities are important to man's development, few can be classed as essential to his very existence as can common salt, a compound of sodium and chloride. Sodium chloride (NaCl), halite in mineralogic terms, is widely distributed throughout the world, a fact that has influenced history and the location of industry. Salt occurs in solution in seawater, in some spring and lake waters, in many subsurface waters, and in solid form in surface and underground deposits. Although seawaters contain the largest reserve of salt and contribute substantial quantities of solar-evaporated salt to the world's annual output, underground bedded and dome deposits supply the largest part of the world's salt requirements.

SUMMARY

Canada is self-sufficient in salt. Production is mainly concentrated in eastern Canada and, although imports are necessary, exports are consistently higher than imports.

Canada is a net exporter of salt, produced principally in eastern Canada. Underground salt deposits have been found in all provinces except British Columbia. They have also been found in the District of Mackenzie, Northwest Territories, and in some of the Arctic islands. Bedded rock salt deposits in southwestern Ontario, Saskatchewan and Alberta, and dome deposits in Nova Scotia are the sources of most of Canada's salt output. In past years, salt has been recovered from brine springs and natural subsurface brines in Nova Scotia, New Brunswick, Ontario, Manitoba, Saskatchewan and Alberta. Salt springs are also common to certain parts of British Columbia.

Canadian production of rock salt, from three underground mines, decreased by 3.3 per cent in 1980 to 4.8 million tonnes (t) because of low usage for melting ice on roads during the mild winter of 1979-80. Fine salt, produced by dissolution and multi-stage vacuum pan evaporation at six plants, totalled 774 012 t, just slightly higher than the previous year, while production of salt in brine, generally used for caustic soda, chlorine and sodium carbonate production, registered an increase of 3.6 per cent from 1.65 to 1.71 million t. A potash refining operation in Saskatchewan sold some of its waste salt for highway de-icing while a potash producer using the solution method sells some of its byproduct salt brine for refining to fine salt.

Imports of salt and salt in brine were down marginally from 1.28 to 1.15 million t. About one-third of this total is in brine.

Potash Company of America produced some common salt associated with its potash mine development activity in New Brunswick.

During 1980, Seleine Mines Inc., continued mine development on the Madeleine Islands, Quebec, with the objective of beginning production in 1982 or early 1983. The company signed a 10-year agreement for export of some salt to the United States.

TABLE 1. CANADA, SALT PRODUCTION AND TRADE, 1979 AND 1980

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Production				
By type				
Mined rock salt	4 952 705	..	4 789 497	..
Fined vacuum salt	745 539	..	774 012	..
Salt content of brines used or shipped	1 645 914	..	1 705 070	..
Total	7 344 158	..	7 268 579	..
Shipments				
By type				
Mined rock salt	4 934 574	64,576,114	4 543 000	..
Fine vacuum salt	735 460	41,070,763	781 000	..
Salt content of brines used or shipped	1 645 914	4,201,240	1 705 000	..
Total	7 315 948	109,848,117	7 029 000	125,845,000
By province				
Ontario	5 623 491	67,900,216	4 800 000	72,358,000
Nova Scotia	998 974	23,100,773	1 018 000	27,862,000
Saskatchewan	291 755	10,951,703	349 000	14,456,000
Alberta	401 728	7,895,425	862 000	11,169,000
Total	7 315 948	109,848,117	7 029 000	125,845,000
Imports				
Salt and brine				
United States	906 742	11,213,000	729 515	9,189,000
Mexico	340 086	2,906,000	387 602	3,680,000
Spain	14 145	291,000	32 822	532,000
Portugal	-	-	858	47,000
Other countries	15 206	413,000	311	81,000
Total	1 276 179	14,823,000	1 151 198	13,529,000
Salt and brine by province of landing				
Newfoundland	28 477	647,655	33 363	553,000
Nova Scotia	563	4,103	596	68,000
New Brunswick	15	1,803	-	-
Quebec	112 558	1,409,516	223 967	2,411,000
Ontario	630 193	6,814,929	331 603	3,970,000
Manitoba	42	2,953	98	10,000
Saskatchewan	676	18,325	852	36,000
Alberta	1 818	68,824	964	17,000
British Columbia	501 837	5,855,159	560 655	6,464,000
Total	1 276 179	14,823,267	1 151 198	13,529,000
Exports				
Salt and brine				
United States	1 798 694	17,000,000	1 625 580	16,891,000
Guyana	8 208	521,000	4 884	850,000
Cuba	2 000	13,000	4 001	252,000
Leeward-Windward Islands	2 856	126,000	1 428	102,000
Barbados	387	20,000	542	33,000
Other countries	9 975	222,000	1 156	100,000
Total	1 822 120	17,902,000	1 637 591	18,228,000

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; .. Not available; - Nil.

TABLE 2. CANADA, SALT SHIPMENTS, 1970, 1975, 1976-80

	Producers' Shipments					
	Mined Rock	Fine Vacuum	In Brine and recovered in Chemical Operations	Total	Imports	Exports
			(tonnes)			($)
1970	3 272 520	552 704	1 036 285	4 861 509	560 659	7,430,000
1975	3 626 123	578 649	1 291 489^r	5 496 261^r	1 183 144	5,185,000
1976	4 354 684	676 191	1 356 892^r	6 387 767^r	1 523 407	9,558,000
1977	4 320 305	681 557	1 435 177^r	6 437 039^r	1 126 225	9,123,000
1978	4 625 528	719 472	1 542 932^r	6 887 932^r	1 330 474	12,888,000
1979	4 934 574	735 460	1 645 914	7 315 948	1 276 179	17,902,000
1980P	4 543 000	781 000	1 705 000	7 029 000	1 151 198	18,228,000

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary; ^{r} Revised

RECOVERY METHODS

Canadian producers employ three different techniques in the recovery of salt and/or brine from depth, the method employed depending upon the nature of the deposit and the type of salt in demand. Conventional underground mining methods are used to mine good-quality rock salt deposits that are relatively shallow and located in areas near large markets that do not specify a high-purity product, or located close to inexpensive, bulk-transportation facilities.

Brining methods, too, are used to recover salt from subsurface deposits, usually from depths exceeding acceptable mining depths. Brine can be evaporated to produce high-purity, fine, vacuum salt, or it can be used directly in the manufacture of chemicals. Salt is also recovered from natural subsurface brines.

The third technique is to recover salt as a coproduct of potash mining, a practice quite common in Europe. In Canada the only commercial application of this technique is at a solution-type potash mine, where production methods permit the recovery of a good-quality salt brine. The other potash producers generally regard the waste salt as unmarketable because of the great distances to major markets, although some shipments have been made for use in snow and ice control.

A fourth method (not used in Canada) is solar evaporation of sea or salty lake waters, a process commonly used in warm, arid climates.

ROCK SALT MINING

Access to rock salt deposits for conventional mining is through vertical shafts, normally about 5 metres (m) in diameter, serving the mining zone at depths of 200 to 600 m. Mining is normally by the room-and-pillar method, the dimensions of the rooms and pillars depending on the depth and thickness of the salt deposit. Rooms vary from 9 to 15 m in width and from 5.5 to 15 m in height, and pillars vary from about 20 to 60 m square. Extraction ranges from 40 to 60 per cent. The mining operations consist of undercutting, drilling, blasting, loading and primary crushing. Underground haulage is generally by trucks and conveyor belts. Milling involves crushing, screening and sizing; at one mine the milling is done underground. The product, ranging in size from about 1 centimetre (cm) to a fine powder, normally has a purity of at least 97 per cent NaCl. Some states in the U.S., as users of highway salt, require a minimum purity of 97.5 per cent. Most of the gypsum, anhydrite and limestone impurities are removed during crushing and screening. Small amounts of the coarser salt fractions are further beneficiated by use of electronic sorters.

TABLE 3. CANADA, SUMMARY OF SALT PRODUCING AND BRINING OPERATIONS

Company	Location	Initial Production	Production* 1980 (1979) (000 tonnes)	Employment 1980	Remarks
Nova Scotia & New Brunswick					
The Canadian Salt Company Limited	Pugwash	1959	926.6 (832.6)	246	Rock salt mining at a depth of 192 metres (m).
	Pugwash	1962	91.0 (85.7)		Dissolving rock salt fines for vacuum pan evaporation.
Potash Company of America	Sussex	1980	142.0 (-)	-	Development salt from a potash mine under construction for production in 1982.
Domtar Inc.	Amherst	1947	92.2 (80.6)	71	Brining for vacuum pan evaporation.
Ontario					
Allied Chemical Canada, Ltd.	Amherstburg	1919	584.3 (587.7)	8**	Brining to produce soda ash.
The Canadian Salt Company Limited	Ojibway	1955	1 679.7 (2 021.3)	246	Rock salt mining at a depth of 300 m.
	Windsor	1892	151.5 (144.7)	139	Brining, vacuum pan evaporation and fusion.
Dow Chemical of Canada, Limited	Sarnia	1950	761.3 (729.0)	10**	Brining to produce caustic soda and chlorine.
Domtar Inc.	Goderich	1959	1 974.7 (2 040.9)	248	Rock salt mining at a depth of 536 m.
	Goderich	1880	102.5 (100.7)	64	Brining for vacuum pan evaporation.

Prairie Provinces

International Minerals & Chemical Corporation (Canada) Limited	Esterhazy, Sask.	1962	63.2 (39.7)	3	Byproduct salt from potash mine for use in snow and ice control.
The Canadian Salt Company Limited	Belle Plaine, Sask.	1969	69.2 (66.9)	28	Producing fine salt from byproduct brine from potash mine.
Prince Albert Pulp Company Ltd.	Saskatoon, Sask.	1968	43.0 (42.1)	5**	Brining to produce caustic soda and chlorine.
Domtar Inc.	Unity, Sask.	1949	161.4 (143.3)	82	Brining, vacuum pan evaporation and fusion.
The Canadian Salt Company Limited	Lindbergh, Alta.	1968	115.4 (114.6)	84	Brining, vacuum pan evaporation and fusion.
Dow Chemical of Canada, Limited	Fort Sask., Alta.	1968	749.8 (287.7)	8**	Brining to produce caustic soda, chlorine, and ethylene storage.
			7 713.7 (7 322.1)	1 242	

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* Shipments; ** Employment part of a chemical complex.

Most of the rock salt mined in Canada is shipped in bulk by water, rail and road, much of it being used for snow and ice control.

BRINING AND VACUUM-PAN EVAPORATION

Underground brining is accomplished by injecting water into a salt deposit to dissolve the salt, then pumping the resulting saturated salt solution to the surface. Water injection and brine recovery can be done through a single borehole with casing and tubing, or through a series of two or more cased wells. A brine field normally has from 2 to 20 wells, depending on the quality of brine needed for the surface operation. Depths of the brine fields in Canada range from 335 to 1 980 m. Saturated salt brine contains 26 per cent NaCl, which equates to about 300 grams (g) of salt per litre (l). At the surface the brine is either evaporated to produce fine vacuum salt, or used directly in the manufacture of chemicals.

Canadian producers use a vacuum-pan process to evaporate the brine and produce fine salt. The brine is purified to remove gypsum and other impurities and fed into a series of three or four large cylindrical steel vessels under vacuum for triple- or quadruple-effect evaporation. The salt crystalizes and is removed as a slurry, washed, filtered and dried. Product purity is generally 99.5 per cent or better.

Final processing involves screening, the introduction of additives, compression into blocks, briquettes or tablets; or compaction, recrushing and packaging to prepare as many as 100 different salt products.

In some cases, salt is melted at a temperature of about 815°C, allowed to cool and then crushed. This product is "fused" salt, which is particularly suitable for use in water softeners. The electrolysis of fused salt produces sodium metal which has many applications including use in detergents.

PRODUCTION AND DEVELOPMENTS IN CANADA

Atlantic region. Salt deposits occur in isolated sub-basins of a large sedimentary basin that underlies the northern mainland of Nova Scotia and extends westward under the bordering areas of New Brunswick, northeastward under Cape Breton Island, Prince Edward Island, the Madeleine Islands and southwestern Newfoundland. The salt beds occur within the Mississippian Windsor Group and are generally folded and faulted. The deposits appear to be steeply dipping tabular bodies, domes and brecciated structures of rock salt.

Salt production in the Atlantic provinces in 1980 was from an underground mine at Pugwash, Nova Scotia and a brining operation near Amherst, Nova Scotia. At Pugwash The Canadian Salt Company Limited mines annually between 800 000 and 1 000 000 t of rock salt destined for Canadian markets. Up to 100 000 tonnes per year (tpy) of salt is dissolved for vacuum pan evaporation and sold for high quality applications including table salt.

Total employment of the company in Nova Scotia in 1980 was 246. Reserves are limited to about 10 years of operation. Domtar Inc. has a high purity salt plant based on brines near Amherst, Nova Scotia. The company employs 72 persons and produces up to 100 000 tpy.

Salt domes in both Richmond and Inverness counties in Nova Scotia have been explored by Domtar Inc., Chemicals Division, and The Dow Chemical Company for gas storage purposes, and early in 1978 Home Oil Company Limited sank two test holes in the McIntyre Lake region near the Strait of Canso to determine oil storage capability. Home Oil, in partnership with Murphy Oil Company Ltd. and North Canadian Oils Limited, had applied for a contract in September 1977 with the United States government to store 100 million barrels of crude oil as part of that country's long-term strategic storage program. It was apparent that additional drilling would be required before the full potential of the area could be determined. In early 1979 Gulf Canada Limited bought out the interest held by Murphy Oil and North Canadian Oils, becoming an equal partner with Home Oil. The marine terminal of Gulf's refinery is only 18 kilometres (km) away from the salt domes. After additional drilling, the company determined in late 1979 that it was feasible to store 80 million barrels of oil at a development cost of approximately $400 million. The U.S. government subsequently reversed its decision on the necessity of storage of this type but there was renewed congressional interest at the beginning of 1980.

In New Brunswick, Potash Company of America (PCA) has a major potash mine under construction at Plumweseep, near Sussex, 60 km east of Saint John. The mine will be in production in late 1982 or early 1983. In addition to potash the company intends to extract common salt at a rate of 400 000 to 500 000 tpy and sell most of the output in eastern United States. The salt will be mined in a separate section of the mine which contains beds of high purity. Cavities created by the extraction of the commercial salt will be backfilled with waste salt from the flotation of the potash. Some development salt was produced in 1980 and sold commercially for highway de-icing.

Denison Mines Limited is bringing another potash mine into production by 1983 in the same region. It is not certain yet whether the mine will have byproduct salt for sale.

Quebec. Seleine Mines Inc. a subsidiary of Quebec Mining Exploration Company (SOQUEM) continued its rock salt mine development program on Grosse-Ile, on Madeleine Islands, during 1980. To March 31, 1981 expenditures and commitments amounted to $40,500,000 out of an expected total of $65,923,000. About 35 per cent of the work was completed. The company announced that it was slightly behind schedule but expected to catch up during 1981 so that production would start in mid-1982. Annual capacity of the mine will be about 1 250 000 t. Most of the salt will be marketed in Quebec under a long term contract with the Department of Highways. In addition, a 10-year contract for 300 000 tpy of highway salt, was signed with Diamond Crystal Salt Co. of St. Clair, Michigan for the U.S. eastern seaboard market.

The Madeleine Islands salt domes are extensive and serious thought is being given to the utilization of the formations for storage of oil, gas and other products. Laduboro Oil Ltd. holds provincial permits to develop such a system of storage reservoirs. This possibility is still under consideration. Potash is known to occur in the southern part of the Islands.

Ontario. Thick salt beds underlie much of southwestern Ontario, extending from Amherstburg northeastward to London and Kincardine, bordering on what is known geologically as the Michigan Basin. As many as six salt beds, occurring in the Upper Silurian Salina Formation at depths from 275 to 825 m, have been identified and traced from drilling records. Maximum bed thickness is 90 m, with aggregate thickness reaching as much as 215 m. The beds are relatively flat-lying and undisturbed, implying low-cost mining.

During 1980, those beds were worked through two rock salt mines, one at Goderich and one at Ojibway, and through brining operations at Goderich, Sarnia, Windsor and Amherstburg. Domtar Inc. through its division, Sifto Salt, started a $37 million expansion project of its Goderich underground salt mine. In November 1980 a $7 million contract was awarded to the Cementation Company (Canada) Limited to sink a new production shaft. The 6.7 m shaft will be the third at the salt mine and when completed by February 1983 it is expected to increase production capacity from 2.0 to 3.1 million tpy. Employment at the mine is expected to increase to about 300 from the current level of 210.

Prairie Provinces. Salt beds underlie a broad belt of the Prairie Provinces extending from the extreme southwestern corner of Manitoba northwestward across Saskatchewan and into the north-central part of Alberta. Most of the salt deposits occur within the Prairie Evaporite Formation, which constitutes the upper part of the Middle Devonian-Elk Point Group, with thinner beds of salt occurring in Upper Devonian rocks. Depths range from 180 m at Fort McMurray, Alberta, to 900 m in eastern Alberta, central Saskatchewan and southwestern Manitoba, and to 1 830 m around Edmonton, Alberta, and in southern Saskatchewan. Cumulative thicknesses reach a maximum of 400 m in east-central Alberta. The beds lie relatively flat and undisturbed. The same rock sequence contains a number of potash beds currently under exploitation in Saskatchewan.

Brine for vacuum-pan evaporation is produced from these formations at two locations - Lindbergh, Alberta and Unity, Saskatchewan - while brine for the production of caustic soda and chlorine is obtained at Saskatoon, Saskatchewan and Fort Saskatchewan, Alberta. In addition, byproduct brine from a potash solution mine at Belle Plaine, Saskatchewan is used in the production of fine vacuum-pan salt by The Canadian Salt Company Limited. International Minerals & Chemical Corporation (Canada) Limited (IMCC) supplies a small quantity of waste salt from the Esterhazy potash mine for snow and ice control on highways.

Serious consideration is being given by some companies to expand brine salt produc-

TABLE 4. WORLD SALT PRODUCTION, 1977-80

	1977	1978P	1979^{e}	1980^{e}
	(000 tonnes)			
United States	39 407	38 915	41 567	40 914
People's Republic of China^{e}	17 237	19 537	19 958	20 865
U.S.S.R.^{e}	14 297	14 497	14 696	14 969
West Germany	12 322	12 658	12 700	13 154
United Kingdom	8 202	7 310	7 348	7 439
France	5 350	6 525	6 876	6 895
Canada	6 437^{r}	6 888^{r}	7 316	7 029
Mexico	4 900	5 635	5 625	5 625
Italy	5 030	4 931	5 080	5 171
Australia	4 715	4 665	4 536	4 627
Poland	4 357	4 395	4 536	4 990
India	3 759	4 380	4 536	4 536
Other countries	32 750	33 851	33 452	36 151
Total	158 365	163 751	167 791	172 365

Sources: U.S. Bureau of Mines, Preprints 1978-79 and U.S. Bureau of Mines Mineral Commodity Summaries, 1981; Energy, Mines and Resources Canada.

P Preliminary; ^{e} Estimated; ^{r} Revised.

tion for chemical uses in the export market. The main opportunity is for additional caustic soda production for the Japanese market; because of energy considerations, that country plans no further capacity increases in its caustic/chlorine industry, preferring to rely on imports for additional needs.

British Columbia. Solar-evaporated salt from Mexico supplies the British Columbia caustic soda and chlorine manufacturing industry. Erco Industries Limited has a plant in North Vancouver; FMC of Canada Limited has one at Squamish and Hooker Chemical Canada Ltd., at North Vancouver.

CANADIAN CONSUMPTION AND TRADE

Salt is marketed in at least 100 different forms, packages and containers, and its direct and indirect uses number in the thousands. The largest single market for salt in Canada is for snow and ice control on highways and city streets. By comparison with other uses, this market is new, having expanded in Canada from less than 100 000 t in 1954 to an estimated 2.5 million t in 1980. However, this market is expected to increase marginally over the next decade.

The next-largest consumer of salt is the industrial chemical industry, particularly for the manufacture of caustic soda (sodium hydroxide) and chlorine. Salt for four caustic soda and chlorine plants is obtained from on-site brining and natural brines; others use mined rock salt or imported solar-evaporated salt. Other industrial chemicals that require significant quantities of salt in the manufacturing process include sodium carbonate (soda ash), sodium chlorate, sodium bicarbonate, sodium chlorite and sodium hypochlorite. Strong growth in this market is expected to continue, based on domestic demand as well as on export opportunities.

The pattern of Canada's salt trade has not changed considerably in the past few years. Because of its low unit value and availability in most key market areas, salt is seldom hauled over long distances, except in the case of seaborne and intercoastal shipments where greater mileage entails little additional cost. Sales of highway salt on the eastern seaboard of the U.S., beginning in 1982 by Seleine Mines Inc. and in 1983 by the Potash Company of America from their respective mines in Quebec and New Brunswick, will increase Canadian exports and replace salt traditionally imported from Mexico and the Caribbean countries.

TABLE 5. CANADA, AVAILABLE DATA ON SALT CONSUMPTION, 1977-1980

	1977	1978	1979	1980e
	(tonnes)			
Snow and ice control[1]	2 600 838	2 368 627	2 984 541	2 472 849
Industrial chemicals	1 947 697	1 987 525	2 209 361	2 342 000
Fishing industry	45 000	51 000	51 000	58 000
Food processing				
Fruit and vegetable processing	19 437	19 120	21 422	21 850
Bakeries	13 705	13 781	13 839	13 700
Fish products	26 889	28 909	28 354	31 000
Dairy products	7 965	11 095	9 128	9 500
Biscuits	2 176	1 765	2 012	2 000
Poultry processors	49	30	40	45
Miscellaneous food preparation	21 493	24 188	42 178	36 850
Grain mills[2]	53 646	59 965	65 308	70 900
Slaughtering and meat processors	43 741	43 714	47 919	51 700
Pulp and paper mills[3]	40 000	38 500	53 000	56 000
Leather tanneries	9 951	9 205	10 217	10 000
Miscellaneous textiles	953	1 691	2 185	2 200
Breweries	236	214	140	150
Total	4 833 776	4 659 329	5 540 644	5 178 744

Sources: Statistics Canada; Salt Institute; Pulp and Paper Canada, April 1980.

[1] Fiscal year ending June 30. [2] Includes feed and farm stock salt in block and base forms. [3] Not included in 1979 Statistics Canada Survey. Figures are estimates as published in "Pulp and Paper Canada".

e Estimated by Energy, Mines and Resources Canada; P Preliminary.

OUTLOOK

Demand for industrial salt is expected to remain good for the longer term. Application of salt for road de-icing and snow control however, appears to have reached a plateau with some indications that usage on a road-kilometre basis may be declining in some provinces. A number of municipalities are experimenting with higher sand to salt ratios. New road construction in North America is also undergoing a significant decline, accentuated further by the recent economic trends. Thus, the overall growth in salt consumption may be in the order of 1.5 to 2.5 per cent.

In its salt industry survey of 1980 the United States Bureau of Mines forecasts an increase of world salt production capacity from 187 million t in 1979 to 236 million t in 1985 which indicates no shortage for this period, since long term growth in demand is forecast by most experts to be in the range of 2.5 per cent to 4 per cent per year. (236 million t corresponds to a 4 per cent growth.)

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
92501-1	Common salt (including rock salt)	free	free	5¢/100 lb.	free
92501-2	Salt for use of the sea or gulf fisheries	free	free	free	free

TARIFFS (cont'd)

CANADA (cont'd)

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
92501-3	Table salt made by the admixture of other ingredients when containing not less than 90 per cent of pure salt	4.9	4.9	15	3
92501-4	Salt liquors and sea water	free	free	free	free

M.F.N. Reductions under GATT (effective January 1 of year given)

	1980	1981	1982	1983	1984	1985	1986	1987
				(%)				
92501-3	4.9	4.8	4.6	4.5	4.4	4.3	4.1	4.0

UNITED STATES, Customs Tariffs (MFN)

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
420.92	Salt in brine	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
420.94	Salt in bulk	2.6	2.3	1.9	1.5	1.1	0.8	0.4	free
420.96	Salt, other	Remains free							

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated (1980), USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241.

Sand and Gravel

D.H. STONEHOUSE

CANADIAN INDUSTRY

Production of sand and gravel in Canada has increased steadily if not spectacularly over recent years, apace with population growth and tied closely to regional construction needs.

During 1980, production was about 270 million tonnes (t) and per capita consumption remained in the range of 11 tpy. Higher labour and transportation costs are reflected in the 12 per cent increase (to over $500 million) in total value assigned to 1980 sand and gravel shipments.

The principal uses for sand and gravel are in highway construction and as concrete aggregate. Output of ready-mix concrete and of most concrete products was again reduced during 1980, as construction in real terms slowed. Housing starts were down to 158,601, the lowest since 1966. Although nonresidential construction showed strength, the net demand for aggregates was down. Individual home construction triggers the need for about 300 t of aggregate per unit while apartment construction requires only about 50 t per unit, according to an Ontario Ministry of Natural Resources study.

Sand and gravel deposits are widespread throughout Canada, and large producers have established "permanent" plants as close to major consuming centres as possible. In addition to large aggregate operations usually associated with some other phase of the construction industry such as a readymix plant or an asphalt plant, there are many small producers serving localized markets. These are often operated on a seasonal or part-time basis. Many larger operations are short-term, intermittently serving as a supply arm of a heavy construction company, and provide material for a given project. Provincial departments of highways operate regional or divisional quarries to supply roadbed material for new and repair work. Exploitation by such a large number of widely diversified groups not only makes control difficult, it also provides great obstacles to the collection of accurate data concerning both production and consumption of sand, gravel and stone.

Although producers' shipments, as recorded by Statistics Canada (catalogue 26-215), reflect the total amounts of sand and gravel recovered by all producers regardless of statistical classification, only about 150 "establishments" are listed, showing a total employment of less than 2,000 persons. More detailed data from individual provincial government departments such as highways, municipal affairs, natural resources, lands and forests are required to reveal the total number of active pit and quarry operations.

SUBSTITUTES

Materials competitive with sand and gravel include crushed stone, slag and the lightweight aggregates, depending on the application considered. It has been estimated that total aggregate consumption in some Canadian urban centres could reach 18 t per

TABLE 1. CANADA, VALUE OF CONSTRUCTION[1] BY PROVINCE, 1979-81

	1979			1980			1981		
	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction ($ 000)	Total	Building Construction	Engineering Construction	Total
Newfoundland	416 092	446 765	862 857	447 694	386 786	834 480	556 139	534 904	1 091 043
Nova Scotia	627 216	452 579	1 079 795	622 763	579 219	1 201 982	761 059	821 399	1 582 458
New Brunswick	594 170	476 357	1 070 527	531 303	433 661	964 964	575 808	469 438	1 045 246
Prince Edward Island	123 280	59 977	183 257	99 614	64 226	163 840	98 496	63 289	161 785
Quebec	4 924 241	4 200 352	9 124 593	5 014 341	4 278 886	9 293 227	5 464 094	4 911 412	10 375 506
Ontario	7 794 586	3 775 774	11 570 360	7 965 310	4 042 331	12 007 641	8 621 518	4 768 029	13 389 547
Manitoba	959 281	510 719	1 470 000	865 835	496 251	1 362 086	832 839	611 990	1 444 829
Saskatchewan	1 217 977	885 247	2 103 224	1 169 326	1 044 053	2 213 379	1 284 539	1 569 280	2 853 819
Alberta	4 717 389	4 655 649	9 373 038	5 073 851	6 144 574	11 218 425	6 080 995	7 523 132	13 604 127
British Columbia, Yukon and Northwest Territories	3 331 675	2 853 540	6 185 215	4 333 442	3 475 690	7 809 132	4 913 854	3 956 488	8 870 342
Canada	24 705 907	18 316 959	43 022 866	26 123 479	20 945 677	47 069 156	29 189 341	25 229 361	54 418 702

Source: Statistics Canada.

[1] Actual expenditures 1979, preliminary actual 1980, intentions 1981.

TABLE 2. CANADA, PRODUCTION (SHIPMENTS) SAND AND GRAVEL BY PROVINCES, 1978 TO 1980

	1978		1979		1980P	
	(000 tonnes)	($000)	(000 tonnes)	($000)	(000 tonnes)	($000)
Newfoundland	4 783	7 452	8 962	15 709	11 000	16 500
Prince Edward Island	981	2 068	774	1 994	1 212	2 607
Nova Scotia	8 917	19 852	9 441	23 280	11 500	27 600
New Brunswick	7 016	10 499	5 256	9 642	8 819	14 800
Quebec	78 913	78 138	79 576	83 784	57 916	70 274
Ontario	89 216	144 253	91 385	153 680	121 254	174 900
Manitoba	13 180	27 974	12 193	26 279	18 188	33 165
Saskatchewan	11 935	16 213	10 232	16 869	14 771	21 976
Alberta	20 898	46 422	25 727	56 044	32 000	67 840
British Columbia	36 253	63 989	41 675	69 839	51 200	81 920
Canada	272 092	416 860	285 221	457 120	327 860	511 582

Source: Energy, Mines and Resources, Canada.
P Preliminary.

TABLE 3. PRODUCTION (SHIPMENTS) OF SAND AND GRAVEL BY USES AND BY AREAS, 1978 AND 1979

		Atlantic Provinces	Quebec	Ontario	Western Provinces	Canada
				(000 tonnes)		
Roads	1978	15 270	48 406	52 052	44 185	159 913
	1979	16 923	47 853	50 530	54 290	169 596
Concrete aggregate	1978	1 488	5 797	12 708	11 111	31 104
	1979	2 753	4 829	15 007	8 673	31 262
Asphalt aggregate	1978	3 255	3 231	6 880	11 980	25 346
	1979	3 175	3 286	7 875	6 339	20 675
Railroad ballast	1978	617	978	457	3 470	5 522
	1979	274	421	76	7 557	8 328
Mortar sand	1978	31	419	1 059	424	1 933
	1979	43	390	1 536	243	2 212
Backfill for mines	1978	88	672	1 536	348	2 644
	1979	-	118	1 135	417	1 670
Other fill	1978	812	5 015	11 868	8 768	26 463
	1979	867	10 542	13 796	8 943	34 148
Other uses	1978	136	14 395	2 656	1 980	19 167
	1979	398	12 137	1 430	3 365	17 330
Total sand and gravel	1978	21 697	78 913	89 216	82 266	272 092
	1979	24 433	79 576	91 385	89 827	285 221

Source: Energy, Mines and Resources Canada.
- Nil.

capita by 1980. Estimates have indicated that available sand and gravel supplies in some regions of southern Ontario will be depleted by the 1990s. This could make outlying deposits not only attractive but necessary to the continued operation of the Canadian construction industry in certain areas. Transportation charges represent from 35 to 58 per cent of consumer costs for over 75 per cent of sand and gravel consumption in southern Ontario, where 90 per cent is moved by truck, according to the Ontario Ministry of Natural Resources. Predicted shortages could also encourage development of underwater deposits.

TECHNOLOGY

Unconsolidated granular mineral material produced by the natural disintegration of rock under weathering and erosion processes is termed either "sand" or "gravel". The terms relate to grain size rather than to composition. Sand is defined very generally as that material passing a 9.51 mm sieve, almost all passing a No. 4 (4.76 mm) sieve, and almost all remaining on a No. 200 (74 micron) sieve. Gravel is that granular material remaining on a No. 4 sieve - the cut-off between commercial sand and gravel. Material finer than 200-mesh is referred to as silt or clay, depending on the particle size.

Commercial sand and gravel deposits are generally classified into one of four categories according to origin or method of deposition. Deposits composed of sand and gravel that have been carried by rivers and streams are referred to as fluvial deposits. They exhibit limited size gradation, and the distribution of size ranges and shapes can vary greatly, depending on whether the streams had been meandering, fast-flowing, narrow or shallow. Glacial deposits were distributed from massive ice sheets over large areas of Canada and the United States as well as in other countries. They consist of rock particles of various types, shapes and sizes and display little sorting or gradation. Marine and lake deposits are usually of hard, tough material, well-segregated and well-rounded. Unstratified mixtures of sand and gravel, covering the complete size range and occurring on the parent rock, are termed residual deposits. These are not usually of commercial importance because of the large amount of softer clays associated with the mass.

TABLE 4. CANADA, EXPORTS AND IMPORTS OF SAND AND GRAVEL, 1978-80

	1978ʳ		1979		1980P	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Exports						
Sand and gravel						
United States	269 058	502,000	323 432	789,000	344 659	744,000
Bermuda	122	13,000	-	-	25 800	85,000
Bahamas	-	-	-	-	12 766	62,000
French Antilles	-	-	-	-	26	14,000
West Germany	-	-	36	7,000	18	7,000
Other countries	36	4,000	172	18,000	262	12,000
Total	269 216	519,000	323 640	814,000	383 531	924,000
Imports						
Sand and gravel, nes						
United States	1 809 915	5,534,000	1 188 955	4,084,000	1 204 816	4,434,000
West Germany	1 020	2,000	5 060	8,000	3 354	11,000
Belgium and Luxembourg	-	-	7 428	73,000	-	-
Netherlands	-	-	454	15,000	-	-
Australia	54	12,000	16	3,000	-	-
Total	1 810 989	5,548,000	1 201 913	4,183,000	1 208 170	4,445,000

Source: Statistics Canada.
P Preliminary; ʳ Revised; - Nil; nes Not elsewhere specified.

TABLE 5. CANADA, SAND AND GRAVEL PRODUCTION (SHIPMENTS) AND TRADE, 1970, 1975-80

	Production	Imports	Exports
		(tonnes)	
1970	183 846 431	456 077	1 125 083
1975	247 155 421	1 909 894	138 452
1976	249 158 891	2 085 922	377 677
1977	262 904 861	1 645 663	273 745
1978	272 091 925	1 810 989^{r}	269 216^{r}
1979	285 221 243	1 201 913	323 640
1980P	327 860 000	1 208 170	383 531

Sources: Energy, Mines and Resources Canada; Statistics Canada.
P Preliminary. ^{r} Revised.

USES

The main uses for sand and gravel are: as fill, granular base and finish coarse material for highway construction, coarse and fine aggregates in concrete manufacture, coarse aggregate in asphalt production, and fine aggregate in mortar and concrete blocks. Specifications vary greatly, depending on the intended use, and many tests are required to determine the acceptability of aggregates for certain applications. Particle size distribution of aggregates, as assessed by grading tests or sieve analysis, affects the uniformity and workability of a concrete mix as well as the strength of the concrete, the density and strength of an asphalt mix, and the durability, strength and stability of the compacted mass when aggregates are used as fill or base-course material. Of importance also are tests to determine the presence of organic impurities or other deleterious material, the resistance of the aggregate to abrasion and to freeze-thaw cycles, the effects of thermal expansion, absorption, porosity, reactivity with associated materials and surface texture.

The use of sand and gravel as backfill in mines continues, along with increasing use of cement and mill tailings for this purpose. Abrasive sands, glass sand, foundry sands and filter sands are also produced.

Even the common products such as sand and gravel require a sales and distribution effort which depends upon forecast data supplied by monitoring relevant indicators. One such indicator is the number of regional housing starts which, in turn, can be projected to determine future needs for roads, driveways, shopping centres and schools. Heavy construction awards can be used to provide an estimate of the quantity of aggregate required for given projects over given periods of time.

PRICES

There is no standard price for sand and gravel. In addition to supply-demand factors prices are determined regionally, or even locally, by production and transportation costs, by the degree of processing required for a given end use and by the quantity of material required for a particular project. Increased land values, reduction of reserves and added rehabilitation expenditures should result in higher prices.

Prices for graded, washed and crushed gravel and sand will show a slow but steady increase, based on greater property costs, more sophisticated operating techniques and equipment, pollution and environmental considerations, and higher labour and transportation costs.

OUTLOOK

Urban expansion has greatly increased demand for sand and gravel in support of major construction. Paradoxically, urban spread has not only tended to overrun operating pits and quarries, but has extended at times to areas containing mineral deposits, thereby precluding the use of these resources. Further complications have arisen in recent years as society has become increasingly aware of environmental problems and the need for planned land utilization. Municipal and regional zoning must be designed to determine and regulate the optimum utilization of land, but must not be designed to provide less than optimum resources utilization. Industry must locate its plants so as to minimize any adverse effects on the environment from their operations. Also, provision must be made for rehabilitation of pit and quarry sites in order to ensure the best sequential land use. The frequency with which small quarries and pits materialize to supply shortlived, local demands, leaving unsightly properties, has prompted action by municipal and provincial governments to control or to prohibit such activity.

Ideally, the exploitation of sand, gravel and stone deposits should be done as part of the total land-use planning package, such that excavations are designed to conform with a master plan of development and even to create new land forms. Inventories indicating the potential available reserves of sand, gravel and stone should be prerequisite to legislation regulating land use. Surveys to locate such resources are being carried out in many provinces in order to optimize their use and to choose the best possible distribution routes to consuming centres. It should be observed that controls and zoning can reduce reserves of these resources significantly.

On average, total aggregate consumption will rise in line with population increases, housing requirements and construction in general. Sand and gravel consumption will continue in competition with crushed stone and, in some applications, with lightweight aggregates. New reserves must be located, assessed and made part of any community development planning or regional zoning, with optimum land and resource utilization in mind. In the search for new sources of sand and gravel some countries are turning to their seabeds. The use of huge pumps and specially equipped ships to draw gravel from the seafloor and deposit it in attendant barges is already common practice in Britain. Such methods of obtaining aggregates can have far-reaching environmental effects.

Selenium and Tellurium

D.A. CRANSTONE

Selenium

Selenium is a nonmetallic element whose chemistry is similar to that of sulphur. It has some of the properties of a metal and is sometimes referred to as a metal. Selenium occurs in minerals associated with copper, lead and iron sulphides. Commercial production is from electrolytic copper refinery slimes and from flue dusts from copper and lead smelters. Thus, selenium production is related to refined copper production and to the relative recovery rates of selenium. Producing countries include the United States, Canada, Japan, the U.S.S.R., Belgium, Sweden, Mexico, Yugoslavia, Finland, Peru, Australia and Zambia. A significant amount of selenium is also produced each year from secondary sources.

Production of selenium from blister copper treated at Canadian refineries plus refined selenium from domestic primary materials was 246 000 kilograms (kg) valued at $11,296,000 in 1980, compared with 217 759 kg valued at $6,908,282 in 1979. In addition, substantial amounts of xerographic scrap and other selenium scrap are imported from the United States and other countries, to be re-refined in Canada and re-exported. In 1980, Canada was the non-communist world's second-largest producer of refined selenium, following Japan. The United States ranks third.

As shown in Table 1, production in 1980 exceeded that in 1979, which was below normal as a result of strikes at the Sudbury operations of Inco Limited and the Mines Gaspé Division of Noranda Mines Limited.

Domestic consumption of selenium in 1980 was reported to be 10 795 kg, compared with 15 772 kg in 1979.

Most of Canada's selenium production is exported but exports vary widely from year to year, often differing significantly from refined production. The United States is Canada's major market, followed by the United Kingdom. These two countries together purchased 75 per cent of Canada's exports in 1980.

Canadian Copper Refiners Limited at Montreal East, Quebec, operates Canada's largest selenium recovery plant. This plant refines copper from the Noranda smelter of Noranda Mines Limited, the Murdochville smelter of Gaspé Copper Mines, Limited, (both in Quebec) and the Flin Flon smelter of Hudson Bay Mining and Smelting Co., Limited in Manitoba. It produces commercial-grade (99.5 per cent) and high-purity (99.99 per cent) selenium and a variety of selenium compounds. Annual capacity is up to 186 600 kg of selenium in elemental form and in salts, depending on copper production and its selenium content.

The 67 200 kg-per-year selenium recovery plant of Inco Limited at Copper Cliff Ontario treats tankhouse slimes from the company's Copper Cliff copper refinery

TABLE 1. CANADA, SELENIUM PRODUCTION, EXPORTS AND CONSUMPTION, 1979 AND 1980

	1979		1980P	
	(kilograms)	($)	(kilograms)	($)
Production				
All forms[1]				
Quebec	174 305	5,529,732	177 000	8,935,000
Manitoba	20 354	645,725	20 000	1,031,000
Ontario	18 325	581,356	44 000	1,101,000
Saskatchewan	4 775	151,469	5 000	229,000
Total	217 759	6,908,282	246 000	11,296,000
Refined[2]	511 703	..	377 204	..
Exports				
United States	158 077	6,818,000	135 579	4,215,000
United Kingdom	95 481	3,789,000	94 347	2,492,000
Japan	8 890	471,000	12 519	595,000
Spain	6 169	169,000	12 927	360,000
Ireland	-	-	3 402	162,000
Puerto Rico	2 676	159,000	17 463	140,000
Other countries	17 917	612,000	30 527	279,000
Total	289 210	12,018,000	306 764	8,243,000
Consumption[3]	15 772	..	10 795	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Recoverable selenium content of blister copper treated at domestic refineries, plus refined selenium from domestic primary materials. [2] Refinery output from all sources, including imported materials and secondary sources. [3] Consumption (selenium content), as reported by consumers.

P Preliminary; .. Not available; - Nil.

and its Port Colborne, Ontario, nickel refinery, and produces minus 200 mesh selenium powder (99.5 per cent Se).

Non-communist world production of selenium in 1980 was 1 383 200 kg compared with 1 562 193 kg in 1979.

In the United States, primary selenium production in 1980 was 226 800 kg compared with 266 300 kg in 1979. The United States imported 40 per cent of its requirements in 1980, up from 28 per cent in 1979, but close to the 43 and 42 per cent in 1978 and 1977 respectively. U.S. producer stocks declined slightly to 272 700 kg in 1980 from 284 400 kg in 1979 but, as the oversupply of selenium that has existed in recent years continued, prices fell during 1980.

USES

Selenium is used in the manufacture of glass, steel, electronic components, explosives, animal and poultry feeds, fungicides and pigments, and in xerography. The 1979 edition of this review contains a more detailed description of selenium uses.

Elemental selenium is marketed in two grades: commercial, with a minimum content of 99.5 per cent Se; and high purity, with a minimum content of 99.99 per cent Se. Other forms include ferroselenium, nickel-selenium, selenium dioxide, barium selenite, sodium selenate, sodium selenite and zinc selenite. Consumption in the United States in 1980, as estimated by the United States Bureau of Mines, was: electronic and

TABLE 2. CANADA, SELENIUM PRODUCTION, EXPORTS AND CONSUMPTION, 1970, 1975-80

	Production			
	All forms[1]	Refined[2]	Exports[3]	Consumption[4]
	(kilograms)			
1970	300 884	387 572	311 209	7 135
1975	182 385	342 392	218 000	9 933
1976	109 649	226 373	240 900	11 212
1977	161 308	410 326	197 500	12 476
1978	122 405	392 777	242 200	14 364
1979	217 759	511 703	289 200	15 772
1980P	246 000	377 204	306 800	10 795

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Recoverable selenium content of blister copper treated at domestic refineries, plus refined selenium from domestic primary materials. [2] Refinery output from all sources, including imported materials and secondary sources. [3] Exports of selenium, metal powder, shot, etc. [4] Consumption (selenium content), as reported by consumers.

P Preliminary.

TABLE 3. NON-COMMUNIST WORLD REFINERY PRODUCTION OF SELENIUM, 1978-80

	1978	1979	1980[e]
	(kilograms)		
Japan	453 600[e]	453 590	453 600
Canada	392 777	511 703	377 200
United States	230 713	266 260	226 800
Mexico	80 000	82 100	81 600
Sweden	68 000[e]	68 040	68 000
Belgium and Luxembourg[e]	60 000	58 900	59 000
Other countries	87 917	121 600	117 000
Total	1 373 007	1 562 193	1 383 200

Sources: U.S. Bureau of Mines **Mineral Commodity Summaries**, 1980, 1981; Energy, Mines and Resources Canada.

[e] Estimated.

TABLE 4. CANADA, INDUSTRIAL USE OF SELENIUM, 1978-80

	1978	1979	1980P
	(kilograms of selenium)		contained
By end-use			
Glass	10 369	9 618	7 642
Other[1]	3 995	6 154	3 153
Total	14 364	15 772	10 795

Source: Energy, Mines and Resources Canada.

[1] Steel, pharmaceuticals.

P Preliminary.

photocopier components, 35 per cent; ceramics and glass, 30 per cent; chemicals and pigments, 25 per cent; and other uses, 10 per cent. U.S. apparent consumption in 1980 was 375 000 kg compared with 371 000 kg in 1979.

OUTLOOK

Canadian production has been dropping because the average selenium content in Canadian ores is declining. Therefore, even though Canadian copper output is rising, selenium production is expected to continue to decline over the medium-term. As indicated by falling prices, demand for selenium is weak, and this situation may continue until there is an improvement in the world economic situation.

Increased recycling of xerographic drums is reducing demand for primary selenium. Prices are expected to remain weak in the short- to medium-term and producer stocks will continue to rise. The development of new uses could eventually strain the available supply but higher prices would encourage efforts to improve recoveries. Selenium tends to volatilize and be emitted as SeO_2 gas during copper smelting, and up to one-half of the selenium content in copper ores is lost in this way. Recovery of this lost selenium is technically feasible, but significantly higher selenium prices would be necessary to make such recovery economic.

PRICES

1980 selenium producer prices, in United States currency, were as follows:

	($US/lb)
Commercial grade, 99.5% minimum, delivered[1]	
January 1 to January 30	10.00-15.00
January 31 to October 6	10.00-12.00
October 7 to December 31	8.50-12.00
High-purity grade, 99.9% minimum, powder, delivered[2]	
January 1 to October 6	13.00
October 7 to December 31	11.50-13.00

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[1] **Metals Week**; [2] American Metal Market.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
92804-4	Selenium	5	10	15	5

MFN Reductions under GATT (effective January 1 of year given)

	1980	1981	1982	1983	1984	1985	1986	1987
				(%)				
92804-4	10.0	10.0	10.0	10.0	10.0	10.0	9.9	9.2

UNITED STATES

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
420.50	Selenium dioxide	Remains	free						
420.52	Selenium salts	Remains	free						
420.54	Other selenium compounds	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
632.40	Selenium metal, unwrought, other than alloys, waste and scrap	Remains	free						
632.88	Selenium metal alloys, unwrought	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5
633.00	Selenium metals, wrought	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5

TARIFFS (cont'd)

EUROPEAN ECONOMIC COMMUNITY

Item No.		1980	Base Rate	Concession Rate
28.04 C.11	Selenium	free	free	free

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated (1980), USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 22, No. L342, 1979.

Tellurium

Tellurium, like selenium, is recovered in Canada from the tankhouse slimes from the two electrolytic copper refineries and the Port Colborne nickel refinery. It is refined by the same two companies, Canadian Copper Refiners Limited at Montreal East, Quebec, and Inco Metals Company at Copper Cliff (Sudbury) Ontario. Although more "metallic" than selenium, tellurium resembles selenium and sulphur in chemical properties and, like selenium, is a semiconductor. Tellurium output is related to selenium output because tellurium is a coproduct of selenium recovery.

Production of tellurium in all forms from Canadian ores in 1980 was 45 000 kg valued at $1,240,000 compared with 42 433 kg valued at $2,191,806 in 1979, but refined output in 1980 was only 8 974 kg compared to 47 204 kg in 1979. The substantial drop in refined production and the large discrepancy between total Canadian tellurium production and Canadian refined production is the result of a significant decline in U.S. and world consumption in 1980, owing to the closure of a chemical plant in Texas in 1979 which resulted in a reduction of the use of tellurium as a catalyst.

Canadian Copper Refiners has an annual capacity of up to 27 200 kg of tellurium in powder, stick, lump and dioxide forms. The Copper Cliff refinery has an annual capacity of up to 8 200 kg of tellurium in the form of dioxide.

USES

Tellurium supply is related to copper production but the nature of demand justifies only a low rate of recovery. Tellurium and many of its compounds are highly toxic and great care is required in their handling.

Most of the commercial-grade tellurium sold by the primary producers is in the form of slab, stick, lump, tablet and powder. It is also sold as copper-tellurium and iron-tellurium alloys. Major uses are as additions to ferrous and nonferrous alloys to improve machineability or otherwise improve their metallurgical properties, when used in rubber products, thermoelectric devices, catalysts, insecticides and germicides, delay blasting caps, glass, ceramics and pigments. The 1979 edition of this reivew contains a more detailed description of tellurium uses.

Normal commercial grades of tellurium contain a minimum of 99 per cent or 99.5 per cent tellurium. Tellurium dioxide is sold in the form of minus 40 to minus 200-mesh powder containing a minimum of 75 per cent tellurium.

In the United States, consumption by major use in 1980 was estimated to be: iron and steel, 65 per cent; nonferrous metals, 20 per cent; chemical uses, 10 per cent; and other uses 5 per cent.

OUTLOOK

Supply of tellurium is largely limited to that which is available from copper output and,

TABLE 5. CANADA, PRODUCTION AND CONSUMPTION OF TELLURIUM, 1970 AND 1975-80

	Production		Consumption
	All forms[1]	Refined[2]	Refined[3]
	(kilograms)		
1970	26 459	29 317	399
1975	19 854	42 253	..
1976	48 698	53 141	..
1977	35 116	37 021	..
1978	31 421	45 299	..
1979	42 433	47 204	..
1980P	45 000	8 974	..

Source: Energy, Mines and Resources Canada.

[1] Includes recoverable tellurium content of blister copper treated, plus refined tellurium from domestic primary materials. [2] Refinery production from all sources, including imported material and secondary sources. [3] Consumption (tellurium content), as reported by consumers.

P Preliminary; .. Not available, withheld to avoid disclosing company data.

as in the case of selenium, new copper production is increasingly derived from tellurium-poor ores. In the short- to medium-term, demand is expected to grow slowly and supply should be adequate to meet requirements. However, as the total available supply of tellurium is even more limited than that of selenium, significant new uses of tellurium, such as in solar collectors, could result in the higher prices that would justify a higher percentage recovery from tellurium-bearing copper ores.

The decline in the world economic situation seems likely to lead to a temporary oversupply of tellurium.

TABLE 6. NON-COMMUNIST WORLD REFINERY PRODUCTION OF TELLURIUM, 1978-80

	1978	1979	1980[e]
		(kilograms)	
Japan	72 600[e]	77 110	77 100
Canada	45 299	47 204	8 970
Hong Kong	..	45 360	45 400
Fiji[e]	22 700	22 680	22 700
Peru	15 400	15 870[e]	15 900
India	..	450	1 400
Total[e1]	156 000	208 700	171 500

Sources: U.S. Bureau of Mines, Mineral Commodity Summaries, 1980 and 1981; Energy, Mines and Resources Canada.

[1] Available data. United States withholds its figures to avoid disclosing company data, but accounted for 42 per cent of world output in 1975.

[e] Estimated; .. Not available.

PRICES

According to **Metals Week**, the 1980 tellurium price for slab in 100-pound lots, in United States currency, was as follows:

	($US/lb)
January 1 to October 6	20.00
October 7 to December 31	18.00-20.00

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
92804-5	Tellurium metal	5	10	15	5

MFN Reductions under GATT (effective January 1 of year given)

	1980	1981	1982	1983	1984	1985	1986	1987
				(%)				
92804-5	10.0	10.0	10.0	10.0	10.0	10.0	9.9	9.2

UNITED STATES

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
427.12	Tellurium Salts	4.8		-	No change		-		4.8
421.90	Tellurium compounds	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
632.48	Tellurium metals, unwrought other than alloys, and waste and scrap	3.5	3.0	2.5	2.0	1.5	1.0	0.5	free
632.88	Tellurium metal alloys, unwrought	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5
633.00	Tellurium metal, wrought	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5

EUROPEAN ECONOMIC COMMUNITY

Item No.		1980	Base Rate	Concession Rate
28.04 C.111	Tellurium metal	2.4%	2.4%	2.1%

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated (1980), USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 22, No. L342, 1979 GATT Documents, 1979.

Silica

B.W. BOYD

Silica (SiO_2) occurs as the mineral, quartz, in a variety of rocks and unconsolidated sediments. Although it is one of the most abundant minerals, making up an estimated 12 per cent of the earth's crust, commercial sources of silica are presently restricted to uncommonly pure sands, sandstones, quartzites and vein quartz. Further, because of its low unit value, an economically viable deposit should normally be mineable by low-cost, open-pit methods and, ideally, be located close to consuming areas in order to minimize transportation costs.

The principal uses for silica are: as the chief constituent in glass, as metallurgical flux, in the manufacture of silicon carbide, as an ore of silicon and ferrosilicon, as foundry sand for metal castings, in sand blasting, and as filler materials in tile, asbestos cement pipe, concrete and bricks.

Production of silica in Canada in 1980 was down 3.6 per cent from 1979 and well below the peak of 2.9 million tonnes (t) produced in 1970. The value increased in pace with general inflation.

About 40 per cent of silica produced in Canada is low-value lump and sand consumed as metallurgical flux. High-quality silica sand suitable for the manufacture of glass is produced by two companies in Canada. Indusmin Limited, the largest, operates beneficiation plants in southern Ontario and Quebec. Steel Brothers Canada Ltd. quarries high-grade silica sandstone on Black Island in Lake Winnipeg and processes the material at the company's plant at Selkirk, Manitoba.

Canada imports high-grade silica sand for use in glass manufacturing, and sand suitable for foundry castings, silex and crystallized quartz and silica brick.

In 1980, imports, mainly from the United States, were down 28 per cent from the peak reached in 1979. The average price per t of the United States material increased by over 25 per cent which may explain some of the reluctance to continue the high level of imports.

PRINCIPAL PRODUCERS AND DEVELOPMENTS

Newfoundland. Newfoundland Enterprises Limited, a subsidiary of ERCO Industries Limited, produces silica from a quarry at Villa Marie on the Avalon Peninsula. The silica is hauled by truck 19 kilometres (km) to Long Harbour where it is used as a flux in the manufacture of elemental phosphorus by ERCO Industries Limited. This plant requires about 150 000 t of silica annually.

New Brunswick. Chaleur Silica Ltd. quarries sand at Bass River, trucks the material 40 km to Petit Rocher for crushing, cleaning, screening and drying and sells the products in a broad area around the plant.

TABLE 1. CANADA, SILICA PRODUCTION AND TRADE, 1979 AND 1980

	1979		1980	
	(tonnes)	($)	(tonnes)	($)
Production, quartz and silica sand				
By province				
Ontario	980 279	8 965,420	967 000[e]	9,100,000[e]
Quebec	606 998	8,927,703	702 862	11,021,827
Manitoba	269 908	2,598,824	252 004	2,536,616
Alberta	..	2,299,288	..	2,592,545
Nova Scotia	..	1,088,000	..	1,419,522
Newfoundland	..	1,710,233	..	635,776
New Brunswick	..	430,000	..	509,110
British Columbia	21 672	319,757	1 129	33,873
Saskatchewan	108 736	239,722	105 200	870,000
Total	2 368 497	26,578 947	2 282 567	28,719,269
By use				
Glass and fiberglass	408 600	7,880,297	..	..
Flux	869 244	2,544,951	..	..
Ferrosilicon	276 754	2,340,920	..	..
Other uses[1]	813 899	13,812,779	..	..
Total	2 368 497	26,578,947	2 282 567	28,719,269
Imports				
Silica sand				
United States	1 650 914	19,352,000	1 177 306	17,336,000
West Germany	353	21,000	6 143	32,000
Other countries	623	21,000	6	3,000
Total	1 651 890	19,394,000	1 183 455	17,371,000
Silex and crystallized quartz				
United States	1 241	175,000	277	274,000
United Kingdom	18	12,000	1	11,000
Other countries	-	-	3	4,000
Total	1 259	187,000	281	289,000
Firebrick and similar shapes, silica				
United States	3 848	1,106,000	3 535	1,951,000
France	149	144,000	408	104,000
Spain	55	27,000	208	99,000
Switzerland	23	22,000	592	79,000
Other countries	821	211,000	33	30,000
Total	4 896	1,510,000	4 776	2,263,000
Exports				
Quartzite				
United States	60 823	362,000	63 161	601,000
South Africa	-	-	5	1,000
Total	60 823	362,000	63 166	602,000

Source: Statistics Canada; Energy, Mines and Resources Canada.

[1] Includes foundry use, sand blasting, silica brick, concrete products, chemical manufacture, building products and silicon carbide.
[e] Estimated; - Nil; .. Not available.

The sand is used as flux and aggregate after crushing and screened product is used in tree nurseries and for sand blasting.

Quebec. Indusmin Limited produces a wide variety of silica products at its mill near Saint-Canut, Quebec. In addition to quarrying Potsdam sandstone adjacent to the Saint-Canut mill, the company quarries a friable Precambrian quartzite from a deposit near Saint-Donat. Material from the Saint-Donat quarry is trucked about 80 km to the Saint-Canut mill for processing. Products produced at Saint-Canut include silica sand suitable for glass and silicon carbide manufacture, foundry sand, and silica flour for use as a filler in tiles, asbestos cement pipe, concrete blocks and bricks.

In January 1980, an ore dryer and dust collector were added to the Saint-Canut plant but annual capacity was not changed.

The silica sand suitable for glass manufacture is marketed in Quebec, while much of the product suitable for use in the construction industry is sold in Ontario. The balance of Quebec's silica sand requirements for glass manufacture is imported from the United States.

Union Carbide Canada Mining Ltd., quarries quartzitic sandstone at Melocheville, Beauharnois County, for use in ferrosilicon manufacture at Beauharnois. Fines from this operation are used in foundry work, cement manufacture and as a metallurgical flux. During the year the company was negotiating the sale of its metallurgical plants at Beauharnois and Chicoutimi; the Melocheville quarry would be included in an eventual sale.

SKW Canada Inc., operates a 52 000 tpy ferrosilicon plant at Bécancour, Quebec. The company obtains its raw material from a high-purity silica deposit 40 km north of Baie St. Paul near La Galette in Charlevoix County, operated by Baskatong Quartz Products Ltd. The silica is shipped by truck via Baie St. Paul to Bécancour. A new quarry at St. Ludger, Quebec is scheduled to open in 1981.

Armand Sicotte & Sons Limited produces about 170 000 tpy at its quarry near Ste-Clotilde, Quebec. The major consumers are manufacturers of elemental phosphorus, cement and ferro-silicon.

Montreal Silica Mines Ltd. began production during the summer of 1977 from unconsolidated Pleistocene sands near Ormstown, 50 km southwest of Montreal. The 50 000 tpy washing, screening and drying plant produces 50, 55 and 65 mesh foundry sand, 24 and 40 mesh sandblasting sand and a 70 mesh product for glass fibre manufacture. Many of the impurities are in the finer sizes, and screening results in a product purity of 93 to 96 per cent SiO_2.

Baskatong Quartz Products Ltd., operated on a scale of between 100 000 and 200 000 tpy in Charlevoix Township.

Quebec Mining Exploration Company (SOQUEM) has been examining the La Galette silica properties north of Baie Saint-Paul for possible exploitation for the silicon and silicon carbide markets.

Ontario. Indusmin Limited quarries a high-grade silica deposit on Badgeley Island in Georgian Bay. The operation has a capacity of approximately 1 million tpy of washed lump silica and fine material. Primary products from the crushing plant are shipped directly to manufacturers of ferrosilicon and silicon metal, and to the Midland grinding plant for further processing.

At Midland, Indusmin maintains a 500 000 tpy grinding and processing plant serving glass, ceramic, chemical and other industries in Ontario.

Manitoba. Steel Brothers Canada Ltd. quarries friable sandstone of the Winnipeg Formation at Black Island in Lake Winnipeg. The sandstone is then barged to the company's processing plant at Selkirk where it is washed, sized and packaged for sale. The company provides silica sand for a large portion of the western Canadian market. Silica sand suitable for the manufacture of glass containers is shipped to Alberta. The majority of the remaining production is consumed in the Manitoba market, largely as foundry sand.

Saskatchewan. Hudson Bay Mining and Smelting Co., Limited obtains silica for smelter flux from Pleistocene glacial sand deposits in Saskatchewan, adjacent to its operations at Flin Flon, Manitoba.

Alberta. Sil Silica Ltd. quarries Pleistocene dune sands at Bruderheim, 65 km northeast of Edmonton. A washing and flotation plant upgrades material running 93 per cent silica, 3 per cent alumina, 1 per cent clay and 0.75 per cent iron oxide, for products suitable for fibreglass manufacture, sand blast-

TABLE 2. CANADA, SILICA PRODUCTION AND TRADE, 1970, 1975-80

	Production	Imports		Exports	Consumption
Year	Quartz and Silica Sand	Silica Sand	Silex or Crystallized Quartz	Quartzite	Quartz and Silica Sand
			(tonnes)		
1970	2 937 498	1 176 199	186	58 917	3 979 305
1975	2 491 715	1 044 160	1 550	39 977	3 510 818
1976	2 395 948	1 337 138	863	47 944	3 077 594
1977	2 316 680	1 101 186	1 219	56 297	3 037 701
1978	2 245 136	1 242 444	1 955	67 775	2 987 736
1979	2 368 497	1 651 890	1 259	60 823	3 546 363
1980	2 282 567	1 183 455	281	63 166	..

Source: Statistics Canada; Energy, Mines and Resources Canada.

.. Not available.

TABLE 3. CANADA, ESTIMATED CONSUMPTION OF SILICA, BY INDUSTRIES, 1978 AND 1979

	1978	1979
	(tonnes)	
Foundry sand	818 602	989 671
Glass manufacture (including glass fibre)	784 305	929 168
Smelter flux[1]	677 494	869 244
Refractory brick mixes, cements	368 385	405 070
Artificial abrasives	170 142	158 761
Metallurgical	44 426	64 142
Chemicals	24 429	24 632
Gypsum products	27 146	5 847
Concrete products	5 072	12 114
Fertilizer, stock poultry feed	2 219	4 416
Other[2]	65 516	83 298
Total	2 987 736	3 546 363

Source: Energy, Mines and Resources Canada.

[1] Producers' shipments of quartz and silica for flux purposes. [2] Includes asbestos products, ceramic products, frits and enamels, paper and paper products, roofing and other minor uses.

ing and foundry use. Since operations started in 1971, capacity has increased to more than 120 000 tpy. Reserves are adequate for many years.

British Columbia. Pacific Silica Limited near Oliver, British Columbia quarried silica for ferrosilicon and silicon metal markets. At the same time tailings from past operation were reprocessed for various markets and sales were made from stocks for the roofing rock, stucco chip, decorative sand and filter sand markets.

Another small quarry in British Columbia is being tested for lump quartz for the ferrosilicon market in Washington.

OUTLOOK

Silica output and consumption declined for eight years to 1978 and recovered only slightly in 1979. Because metallurgical flux constitutes more than half of silica production, a recovery in the base-metal industries would be necessary to boost silica tonnages significantly.

The outlook is for a continuation of the growth in output of higher-quality silica products through increases in domestic and United States demand and replacement of imports. Interest in silica in eastern Ontario followed a recent in-depth evaluation by the Ontario Ministry of Natural Resources of several promising deposits. Activity in the La Galette area northeast of Quebec City, the Madeleine Islands deposits and occurrences south of Montreal may result in an additional producer in the coming years. Recovery in the nonferrous smelting industry and improvement in general economic conditions should result in stronger growth over the medium-term; in the long-term, the new fibre optics technology is likely to become an important consumer of silica, although significant improvements in mineral processing technology would be required for any of the current Canadian operations to meet the stringent raw material specifications.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
29500-1	Ganister and sand	free	free	free	free
29700-1	Silex or crystallized quartz, ground or unground	free	free	free	free

UNITED STATES

Item No.		
513.14	Sand, other	free
514.91	Quartzite, whether or not manufactured	free
523.11	Silica, not specially provided for	free

		1980	1981	1982	1983	1984	1985	1986	1987
		¢ per long ton							
513.11	Sand containing 95% or more silica, and not more than 0.6% of oxide of iron	22	19	16	12	9	6	3	free

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated 1980, USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241.

Silicon, Ferrosilicon, Silicon Carbide and Fused Alumina

D.G. LAW-WEST

Silicon is the second most abundant chemical element in the earth's crust and world resources of this metal are almost inexhaustible. Silica deposits (SiO_2) are the main commercial source of silicon. The production of silicon metal, ferrosilicon and silicon carbide from silica ores requires large amounts of electricity and therefore production plants are usually situated in areas with an abundant supply of electrical power. In Canada these silicon products are manufactured in plants in Quebec and southern Ontario.

CANADA

The three major Canadian producers of ferrosilicon, namely Chromasco Limited, Union Carbide Canada Limited and SKW Canada Inc., all operate plants in Quebec.

During 1980, Chromasco Limited produced about 38 000 tonnes (t) of ferrosilicon, consisting of 50, 75 and 85 per cent silica (Si) grades. The bulk of Chromasco's output is consumed at its Haley, Ontario plant in the production of magnesium.

Union Carbide Canada Limited (UCC) operates ferroalloys plants at two locations in Quebec. At Beauharnois the company produced 5 400 t of silicon metal and 27 000 t of 50 per cent grade ferrosilicon in 1980. The Chicoutimi plant produced some 24 000 t of ferrosilicon, most of which was the 75 per cent grade.

SKW Canada Inc. started production in 1976 and, as the most recent producer in North America, SKW represents the state of the art in ferrosilicon and silicon metal production. During 1980 the company operated its Bécancour plant at full capacity to produce 25 000 t of silicon metal and 25 000 t of ferrosilicon, mostly 75 per cent grade. SKW Canada is 85 per cent owned by SKW-Trostberg of West Germany and 15 per cent by A/S Ila Og Lilleby Smelteverker of Norway. Most of its production is exported to the United States, West Germany and Japan.

The availability of electrical energy also enables Canada to produce and export bulk quantities of synthetic abrasives such as silicon carbide (SiC) and fused alumina (Al_2O_3). Producers of these abrasives are located in Quebec and Ontario. The Quebec-based companies, with products shown in brackets, are: Canadian Carborundum Company, Limited, Shawinigan (SiC); Norton Company (SiC) and Electro Refractories & Abrasives Canada Ltd., both in Cap-de-la-Madeleine (SiC); and Unicorn Abrasives of Canada Limited, Arvida (Al_2O_3). The Ontario-based companies are: Canadian Carborundum Company (Al_2O_3), Norton Company (Al_2O_3 and SiC) and Usigena (Canada) Limited (Al_2O_3 and SiC), all of Niagara Falls; and The Exolon Company of Canada, Ltd., Thorold (Al_2O_3 and SiC). All Canadian production of synthetic abrasives is exported, principally to the United States where the bulk material is crushed, screened and classified. A small part of the processed material is reimported for the production of bonded abrasives such as abrasive wheels and coated abrasives such as sandpaper.

USES

Silicon metal is used principally as an alloying agent for aluminum. It increases fluidity and corrosion resistance as well as thermal and electrical conductivity. In addition, silicon metal reduces the specific density and thermal expansion of aluminum alloys. These alloys are used principally to make aluminum castings, and contain on average about 6 per cent silicon. More than one-half of the cast aluminum tonnage is used in the transportation industry. Another important use of silicon metal is in the fabrication of silicones, which are used in oil production and for the manufacture of more than 200 products, including synthetic rubber resins and electric motor insulation. Silicon metal is also used to make silicon bronze, aluminum alloys for coating steel sheets, semiconductor electronic devices and silicon nitride (Si_3N_4).

The iron and steel industry is the largest user of ferrosilicon and other silicon alloys such as silicocalcium, silicochrome and silicomanganese. Ferrosilicon functions primarily as a deoxidizer in molten steel. In addition, it is used as a graphite promoter during the production of carbon steels, as an additive to improve the electrical properties of electric steels and as a reducing agent in the manufacture of non-ferrous alloys. Carbon steel contains, on the average, 0.755 kilograms (kg) of silicon per t of steel, and consumes about one-third of Canadian ferrosilicon production. Stainless steels and electric steels, which contain an average of 10 and 20 kg of silicon respectively per t of steel, and other types of steel consume the remaining two-thirds. Ferrosilicon is also used in the silicothermic process for the production of other metals, but only small tonnages are required for this purpose.

TABLE 1. CANADA, FERROSILICON, SILICON CARBIDE AND OTHER FERROALLOYS[1], EXPORTS AND IMPORTS, 1979 AND 1980

	1979		1980P	
	(tonnes)	($000)	(tonnes)	($000)
Exports				
Ferrosilicon				
Japan	5 553	4,583	21 290	15,697
United States	31 550	14,806	21 577	12,253
West Germany	2 634	2,063	1 297	1,339
Italy	-	-	1 012	845
Australia	132	88	787	756
United Kingdom	310	208	801	582
India	-	-	3 116	476
U.S.S.R.	-	-	337	452
Other countries	553	214	1 947	1,466
Total	40 732	21,962	52 164	33,866
Silicon carbide, crude and grains				
United States	82 291	30,378	69 719	31,908
Japan	1 419	581	2 446	1,208
Australia	-	-	103	60
Taiwan	264	108	128	52
Other countries	462	191	18	16
Total	84 436	31,258	72 414	33,244
Ferroalloys, nes				
United States	3 459	5,056	2 302	5,036
Belgium and Luxembourg	10	140	133	1,333
Netherlands	1 020	975	53	424
Japan	89	1,092	1 741	236
Sweden	-	-	16	218
United Kingdom	2 330	596	1 659	201
Other countries	169	439	330	262
Total	7 077	8,298	6 234	7,710

TABLE 1 (cont'd)

	1979		1980P	
	(tonnes)	($000)	(tonnes)	($000)
Imports				
Ferrosilicon				
United States	17 815	12,031	17 170	12,320
France	228	269	409	609
Brazil	17	17	444	433
Norway	1 452	1,412	441	416
West Germany	48	84	36	91
Sweden	280	231	-	-
Total	19 840	14,044	18 500	13,869
Silicomanganese, including silico spiegel				
United States	12 079	7,054	12 086	7,995
Norway	6 776	3,551	4 050	2,430
Portugal	-	-	1 720	1,589
South Africa	1 521	822	3 043	1 424
Brazil	1 500	919	-	-
Total	21 876	12,346	20 899	13,438
Ferroalloys, nes				
United States	4 090	7,880	3 447	8,441
Greece	-	-	3 794	8,334
Brazil	654	4,879	909	8,164
France	1 751	2,734	2 103	3,756
Chile	-	-	10	402
West Germany	77	119	224	313
United Kingdom	44	317	16	177
Sweden	...	21	...	15
Other countries	83	234	-	-
Total	6 699	16,184	10 503	29,602

Source: Statistics Canada.

[1] Other important ferroalloys are discussed in the manganese, nickel and titanium reviews for 1980.

nes Not elsewhere specified; - Nil; P Preliminary; ... Less than one tonne.

TABLE 2. CANADA, CONSUMPTION, EXPORTS, IMPORTS AND PRODUCTION OF FERROSILICON, 1970, 1975-80

	Consumption[1]	Exports		Imports		Production[2]
	(tonnes)	(tonnes)	($ 000)	(tonnes)	($ 000)	(tonnes)
1970	50 556	45 345	8,284	9 477	2,386	86 424
1975	54 904	29 029	8,075	26 353	15,665	57 580
1976	61 734	34 673	11,416	10 424	7,121	85 983
1977	63 521	45 490	17,225	9 131	5,552	99 880
1978	63 931	60 146	27,053	10 487	7,890	113 590
1979	61 928	40 732	21,962	19 840	14,044	82 820
1980P	..	52 164	33,866	18 500	13,869	..

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Consumption as reported by consumers. [2] Consumption, plus net exports, equals derived production.

P Preliminary; .. not available.

OUTLOOK

The market forecast for silicon metal and for ferrosilicon is closely related to the outlook for aluminum and steel respectively.

In the case of silicon metal, about 75 per cent is consumed by the aluminum industry, which is forecast to show a strong growth trend during the next several years. It is expected that the transportation industry, the main consumer of silicon-aluminum alloys, will be an expanding market for these lightweight alloys.

Ferrosilicon demand is determined mainly by the iron and steel industry, and to some extent by manufacturers of magnesium using the silicothermic process. Slow production expansion in the short-term and only moderate growth in the longer-term is expected for these industries.

Potential areas for expanding silicon metal consumption include the electronics industry, where high purity silicon metal is used to produce silicones; the alloy industry, where silicon has scope to substitute for other metals; and the solar energy field, where silicon alloys are widely used in heat exchanger systems.

TABLE 3. CANADA, MANUFACTURERS' SHIPMENTS OF CRUDE SILICON CARBIDE 1970, 1975-79

	(tonnes)	($ 000)
1970	104 113	17,653
1975	89 346	24,597
1976	99 195	32,116
1977	104 011	36,965
1978	106 763	38,763
1979	101 265	44,108

Source: Statistics Canada.

TABLE 4. CANADA, EXPORTS OF SILICON CARBIDE, CRUDE AND GRAINS, 1970, 1975-80

	(tonnes)	($ 000)
1970	96 159	15,976
1975	78 615	17,441
1976	86 455	23,743
1977	86 016	28,511
1978	107 351	33,818
1979	84 436	31,258
1980P	72 414	33,244

Source: Statistics Canada.
P Preliminary

TABLE 5. CANADA, MANUFACTURERS' SHIPMENTS OF CRUDE FUSED ALUMINA 1970, 1975-79

	(tonnes)	($ 000)
1970	131 364	18,088
1975	110 736	26,162
1976	141 695	39,966
1977	139 859	41,977
1978	154 303	49,916
1979	152 118	51,206

Source: Statistics Canada.
P Preliminary.

TABLE 6. CANADA, EXPORTS OF FUSED ALUMINA, CRUDE AND GRAINS, 1970, 1975-80

	(tonnes)	($ 000)
1970	152 572	23,234
1975	127 658	26,650
1976	154 003	38,844
1977	154 291	43,087
1978	167 344	48,830
1979	183 124	55,138
1980P	166 331	55,867

Source: Statistics Canada.
P Preliminary.

PRICES

AS PUBLISHED BY **METALS WEEK** IN DECEMBER; 1979 AND 1980

		1979	1980
		(¢US)	
Ferrosilicon, U.S. producer, per pound of silicon content; lump bulk lots, fob shipping point			
High-purity 75% Si		46.25	46.25
Regular 50% Si		42.00	42.00
Silicon metal, per pound contained silicon, fob shipping point, lump, bulk and carload lots,			
(% max. Fe)	(% max. Ca)		
0.35	0.07	59.70	64.05
0.50	0.07	57.85- 58.85	62.00
1.00	0.07	56.50	59.50

PRICES PUBLISHED BY **AMERICAN METAL MARKET** IN DECEMBER; 1979 AND 1980

	1979	1980
	(¢US)	
SMZ alloy: 60-65% Si, 5-7% Mn, 5-6% Zr, ½ in. x 12 M, per pound of alloy	42.50	45.50
Calcium-silicon and calsibar alloy, fob producer, 15-ton lots, per pound	71.00	71.00
	($US)	
Electric furnace silvery pig iron, fob Keobuck, Iowa		
16% Si, per ton	210.00	210.00
20% Si, per ton	237.00	237.00

PRICES PUBLISHED BY **INDUSTRIAL MINERALS** IN DECEMBER; 1979 AND 1980

(tonnes, cif main European port)	1979	1980
	(£)	
Fused alumina, 8-220 mesh, cif		
Brown, min. 94% Al_2O_3	315-325	380-400
White, min. 99.5% Al_2O_3	350-380	450-500
Silicon carbide, 8-220 mesh, cif		
Black, about 99% SiC	560-580	650-670
Green, over 99.5% SiC	710-730	800-820

fob Free on board; cif Cost, insurance and freight.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(cents)		
37502-1	Silicomanganese - silico spiegel and other alloys of manganese and iron containing more than 1%, by weight, of silicon per pound or fraction thereof, on the manganese contained therein	free	0.75	1.75	free
37503-1	Ferrosilicon, being an alloy of iron and silicon containing 8% or more, by weight of silicon and less than 60%, per pound or fraction thereof, on the silicon contained therein	free	free	1.75	free
37504-1	Ferrosilicon, being an alloy of iron and silicon containing 60% or more, by weight, of silicon and less than 90%, per pound or fraction thereof, on the silicon contained therein	free	0.75	2.75	free
37505-1	Ferrosilicon, being an alloy of iron and silicon containing 90% or more, by weight, of silicon per pound or fraction thereof, on the silicon contained therein	free	2.5	5.5	free
92804-1	Silicon metal	10%	14.3%	25%	9.5%
92815-4	Silicon sulphide	10%	14.3%	25%	9.5%

MFN Reductions under GATT (effective January 1 of year given)

	1980	1981	1982	1983	1984	1985	1986	1987
				(cents)				
37502-1	0.75	0.75	0.74	0.73	0.73	0.72	0.71	0.7
37504-1	0.75	0.75	0.74	0.73	0.73	0.72	0.71	0.7
37505-1	2.5	2.5	2.4	2.3	2.3	2.2	2.1	2.0
				(%)				
92804-1	14.3	13.6	12.8	12.1	11.4	10.7	9.9	9.2
92815-4	14.3	13.6	12.8	12.1	11.4	10.7	9.9	9.2

UNITED STATES (MFN)

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
				(% unless otherwise specified)					
519.21	Crude silicon carbide	Remains free							
519.37	Silicon carbide in grains, ground, pulverized or refined	0.3¢/lb.				- no change -			0.3¢/lb.
606.35	Ferrosilicon, containing 8-60% silicon	Remains free							

TARIFFS (cont'd)

UNITED STATES (MFN) (cont'd)

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
				(% unless otherwise specified)					
606.36	Ferrosilicon, containing 60-80% silicon and over 3% calcium	per lb. on Si content 0.5¢	0.5¢	1.1	1.1	1.1	1.1	1.1	1.1
606.37	Other ferrosilicon containing 60-80% silicon	0.5¢	0.5¢	1.6	1.6	1.6	1.6	1.5	1.5
606.39	Ferrosilicon containing 80-90% silicon	1.0¢	1.0¢	1.9	1.9	1.9	1.9	1.9	1.9
606.40	Ferrosilicon containing over 90% silicon	2.0¢	2.0¢	9.3	8.6	7.9	7.2	6.5	5.8
606.42	Ferrosilicon chromium	10.0				- no change -			10.0
606.44	Ferrosilicon manganese	per lb. on Mn content .46¢ +3.5%	.46¢ +3.5%	5.2	5.0	4.7	4.4	4.2	3.9

EUROPEAN ECONOMIC COMMUNITY (MFN):

Item No.		1980	Base Rate	Concession Rate
			(%)	
28.13	Silicon dioxide	6.2	6.4	4.6
73.02	Ferrosilicon	10.0	10.0	6.2
	Ferrosilico-manganese	5.5	5.5	5.5
	Ferrosilico-chrome	7.0	7.0	4.9

JAPAN (MFN)

Item No.				
28.04	Silicon - single crystal	10.8	15.0	7.2
	- other	5.7	7.5	4.9
28.56	Silicon carbide	5.7	7.5	4.9
68.06	Abrasive paper	10.6	15.0	6.5
73.02	Ferrosilicon	3.9	5.0	3.7

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated (1980), USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241; Customs Tariff Schedules of Japan, 1979; GATT Documents, 1979; Official Journal of the European Communities, Vol. 22, No. L342, 1979.

Silver

J.J. HOGAN

Canada's primary production of silver is derived largely as a byproduct of base-metal ores. Production in 1980 was 1 037 000 kilograms (kg) compared with 1 146 908 kg in 1979. The main factors responsible for the lower output were labour strikes at two major silver producers, sharply lower output from the silver mines in the Northwest Territories, and lower output at Cominco Ltd. because of problems at its lead smelter at Trail, British Columbia.

The value of Canadian silver production in 1980 was $818 million, an increase of 71 per cent over the 1979 value of $478.4 million. Action by speculators, especially in the early part of the year, was responsible for a sharp rise in the silver price which reached an all-time high of $US 48.00 in January.

Ontario was by far the leading silver-producing province, primarily because of substantial byproduct silver produced at the Kidd Creek base-metal mine of Texasgulf Canada Ltd. and the copper-zinc-silver mines in northwestern Ontario. The province accounted for over 43 per cent of Canada's total output. Other major producing provinces or territories were British Columbia, 18 per cent; Yukon Territory, 12 per cent; and New Brunswick, 12 per cent.

Canada's exports of silver in ores and concentrates and as refined metal totalled 1 279 043 kg in 1980, 48 497 kg less than in 1979. The United States continued to be the major market for Canadian exports, accounting for more than 83 per cent of total exports in 1980. About 99 per cent of Canada's refined metal exports in 1980 were made to the United States.

Canada's imports of refined silver in 1980 were 338 997 kg compared with 37 173 kg in 1979. The sharp increase in silver imports, 96 per cent from the United States, reflects movements of silver on the international market for storage and other reasons. Imports of silver in ores and concentates were 146 755 kg in 1980 compared with 78 242 kg in 1979. Shipments from Peru were responsible for the large increase in 1980.

Canadian consumption of silver for both industrial uses and coinage in 1980 was estimated to be 269 052 kg compared with 251 985 kg in 1979. However, there was a significant decline in the use of silver in sterling and silver alloys. The Royal Canadian Mint in 1979 consumed 6 286 kg of silver in the production of 539,617 numismatic silver dollar coins which commemorated the centenary of the transfer from the United Kingdom to Canada of a large part of the Canadian Arctic Territories. Each coin contains 50 per cent silver, the weight of silver being about 11.66 grams (g).

DOMESTIC PRODUCTION

Mine Production

The principal source of silver was as a byproduct of base-metal ores, which accounted for over 85 per cent of the total output

TABLE 1. CANADA, SILVER PRODUCTION, TRADE AND CONSUMPTION, 1979 AND 1980

	1979		1980P	
	(kilograms)	($)	(kilograms)	($)
Production[1]				
By province and territories				
Ontario	411 947	171,831,747	450 000	354,161,000
British Columbia	214 151	89,326,905	188 000	148,488,000
Yukon Territory	129 982	54,218,064	128 000	101,165,000
New Brunswick	187 138	78,059,329	124 000	97,649,000
Quebec	72 886	30,402,202	60 000	47,038,000
Northwest Territories	83 358	34,770,651	46 000	36,368,000
Manitoba	25 725	10,730,288	27 000	21,469,000
Newfoundland	14 247	5,942,561	9 000	7,408,000
Saskatchewan	7 469	3,115,440	5 000	4,215,000
Alberta	5	2,283	-	-
Total	1 146 908	478,399,470	1 037 000	817,961,000
By source[2]				
Base-metal ores	1 117 186	466,002,085	1 013 000	798,390,000
Gold ores	6 685	2,788,186	6 000	4,706,000
Silver-cobalt ores	22 870	9,539,555	18 000	14,865,000
Placer gold ores	167	69,644	..	..
Total	1 146 908	478,399,470	1 037 000	817,961,000
Refined silver[3]	949 778	..	985 051	..
Exports				
Silver in ores and concentrates				
United States	210 109	41,920,000	194 069	79,235,000
Japan	120 675	37,226,000	120 343	63,479,000
Belgium-Luxembourg	9 088	1,835,000	24 417	12,651,000
United Kingdom	8 941	2,194,000	8 293	5,964,000
U.S.S.R.	10 128	3,059,000	9 263	4,615,000
West Germany	41 510	6,185,000	13 621	4,557,000
Italy	9 411	1,599,000	7 733	3,326,000
Other countries	6 532	1,495,000	19 614	9,068,000
Total	416 394	95,513,000	397 353	182,895,000
Refined metal				
United States	904 056	349,651,000	870 535	696,599,000
France	-	-	1 609	2,561,000
Belgium-Luxembourg	-	-	4 480	2,247,000
Switzerland	-	-	1 438	1,370,000
United Kingdom	1 286	356,000	1 245	970,000
Others	5 804	1,691,000	2 383	1,388,000
Total	911 146	351,698,000	881 690	705,135,000
Imports				
Silver in ores and concentrates				
Peru	-	-	67 925	40,087,000
United States	34 601	9,382,000	31 088	26,257,000
Other countries	43 641	15,964,000	47 742	26,377,000
Total	78 242	25,346,000	146 755	92,721,000

TABLE 1. (cont'd.)

	1979		1980P	
	(kilograms)	($)	(kilograms)	($)
Imports (cont'd)				
Refined metal				
United States	33 255	4,381,000	326 301	187,125,000
Peru	-	-	9 235	13,707,000
United Kingdom	3 081	540,000	2 558	839,000
Others	837	160,000	903	575,000
Total	37 173	5,081,000	338 997	202,246,000
Consumption, by use				
Sterling	35 799	..	32 502	..
Silver alloys	43 856	..	39 408	..
Wire rod	4 408	..	3 233	..
Others[4]	167 922	..	193 909	..
Total	251 985	..	269 052	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Includes recoverable silver in: ores, concentrates and matte shipped for export; crude gold bullion produced; blister and anode copper produced at Canadian smelters; and base and other bullion produced from domestic ores. [2] Estimated by Energy, Mines and Resources Canada; the base-metal category includes production of some mines normally regarded as silver producers, but which also recover some base-metal. [3] From all sources, domestic and imported materials of both primary and secondary origin. [4] Includes sheet, coinage, fabricated investment bars and miscellaneous uses.
P Preliminary; - Nil; .. Not available.

TABLE 2. CANADA, SILVER PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975-80

	Production		Exports			Imports,	Consumption[3]
	All Forms[1]	Refined[2] Silver	In Ores and Concentrates	Refined Silver	Total	Refined Silver	Refined Silver
				(kilograms)			
1970	1 376 354	955 668	678 676	752 689	1 431 365	134 347	187 679
1975	1 234 642	931 540	471 410	713 566	1 184 976	420 078	642 089
1976	1 281 437	1 023 928	435 790	947 413	1 383 203	59 136	551 212
1977	1 313 684	987 510	464 075	1 141 857	1 605 932	33 004	298 724
1978	1 266 927	1 026 998	479 724	1 070 284	1 550 008	36 001	329 320
1979	1 146 908	949 778	416 394	911 146	1 327 540	37 173	251 985
1980P	1 037 000	985 051	397 353	881 690	1 279 043	338 997	269 052

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Includes recoverable silver in: ores, concentrates and matte shipped for export; crude gold bullion produced; blister and anode copper produced at Canadian smelters; and base and other bullion produced from domestic ores. [2] From all sources, domestic and imported materials of both primary and secondary origin. [3] In some cases includes only partial consumption for coinage.
P Preliminary.

(statistics on production by source in Table 1 group some predominantly silver mines in the base-metal category). The remainder was derived from mines whose primary product was silver and from lode and placer gold ores. The principal mine producers of silver in Canada are listed in Table 4, while the map "Silver Producers in Canada 1980" shows their approximate locations. The four largest silver mine producers in Canada for 1980, in declining order of output, were: Texasgulf Canada Ltd., in Ontario, by far the largest; Brunswick Mining and Smelting Corporation Limited, in New Brunswick; Cominco Ltd. (Sullivan Mine) in southeastern British Columbia and Cyprus Anvil Mining Corporation in the Yukon Territory. These mines accounted for about 52 per cent of Canadian primary silver production. The Cobalt district, once a major producer of silver, is now a relatively small silver producing district, accounting for only 3 per cent of Canada's 1980 output.

Metal Production

Production of refined silver in 1980 at six Canadian primary silver refineries is shown in Table 3.

Canadian Copper Refiners Limited at Montreal East, Quebec, was Canada's largest producer of refined silver, mainly from the treatment of copper anodes and blister copper and the further refining of lower-grade silver bullion. The silver refinery of Cominco Ltd. at Trail, British Columbia, was the second largest producer, recovering byproduct silver in the processing of its own, as well as custom lead and zinc ores and concentrates. Other producers of refined silver were Inco Metals Company at Copper Cliff, Ontario (from nickel-copper concentrates), and the Royal Canadian Mint at Ottawa, Ontario (from gold bullion). At Cobalt, Ontario, Canadian Smelting & Refining (1974) Limited recovered silver from silver-cobalt ores and concentrates produced in that area. At Belledune, New Brunswick, the Smelting Division of Brunswick Mining and Smelting Corporation Limited recovered byproduct silver from lead concentrates treated in a blast furnace.

At its electronic materials plant at Trail, Cominco also produced a high-purity silver metal with metallic impurities totalling one part per million or less. This specialty metal product was manufactured mainly for applications such as solder preforms, brazing preforms and lead wire in the electronics industry.

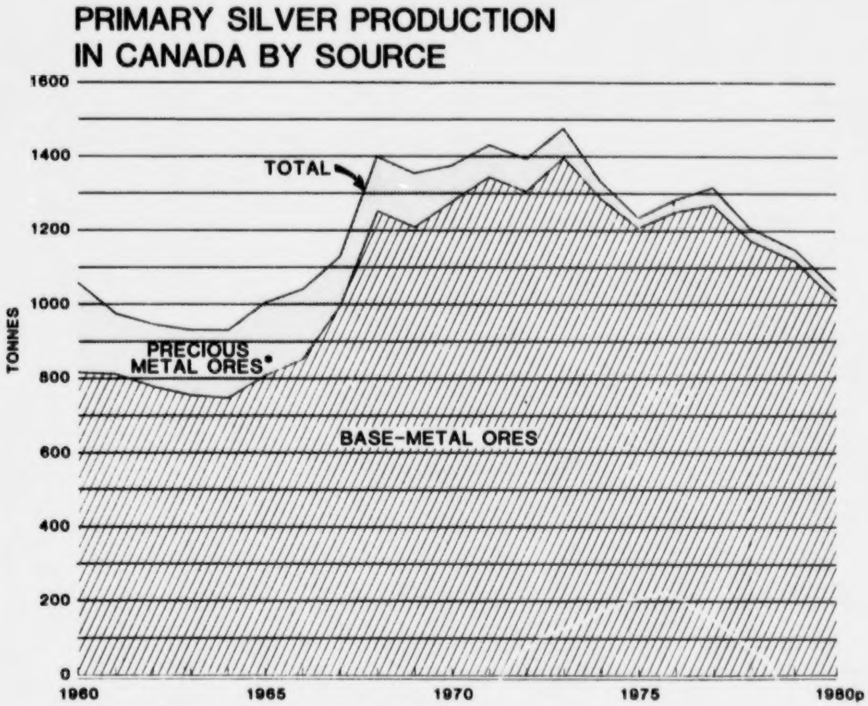
TABLE 3. CANADA, SILVER REFINERY PRODUCTION AND CAPACITY

	Production[1] Refined Silver	Annual[2] Rated Capacity
	(kilograms)	
Brunswick Mining and Smelting Corporation Limited, Smelting Division, Belledune, New Brunswick	94 646[3]	125 000
Canadian Copper Refiners Limited, Montreal East, Quebec	685 987	777 600
Canadian Smelting & Refining (1974) Limited Cobalt, Ontario	39 501	186 600[4]
Cominco Ltd., Trail British Columbia	277 350	373 200
Inco Metals Company Copper Cliff, Ontario	43 545[5]	..
Royal Canadian Mint Ottawa, Ontario	3 924[6]	217 705[7]

Sources: Company Reports; Royal Canadian Mint.

[1] Production of refined silver includes silver produced or derived from domestic and imported ores and concentrates as well as secondary materials. The largest portion of such refined silver was however, derived, from domestic ores and concentrates. [2] As of December 31, 1979. [3] Bullion produced by Brunswick Mining and Smelting Corporation Limited was shipped to Canadian Copper Refiners Limited (CCR) for further refining and the 642 225 kg of silver reported as production for CCR includes all of that silver bullion produced by Brunswick and refined by CCR in 1979. [4] Up to this amount, depending on nature of material processed. [5] Silver delivered to market. [6] Silver derived from refining gold bullion. [7] Total capacity for producing refined gold and silver, of which about 10 per cent is silver.

.. Not available.


PRIMARY SILVER PRODUCTION IN CANADA BY SOURCE

* Mostly from Silver-cobalt ores, some from Gold ores.
p Preliminary

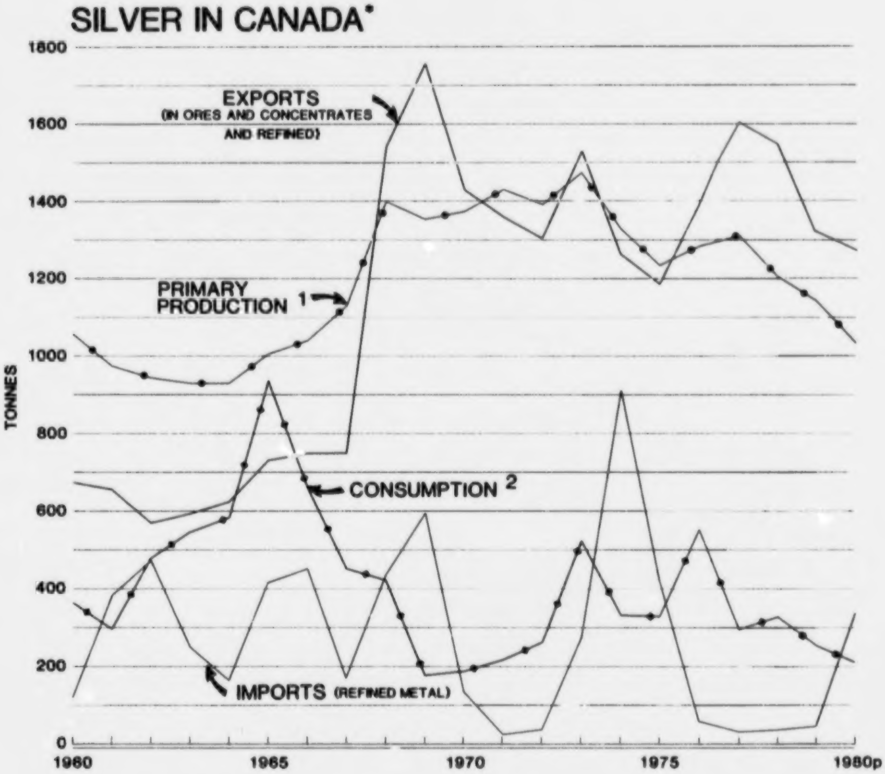
Figure 1

CANADIAN DEVELOPMENTS

Atlantic Provinces. Silver production in the Atlantic provinces was considerably lower in 1980 than the previous year, largely because of the strike at the mine operations of Brunswick Mining and Smelting in New Brunswick.

The two small silver producers in Newfoundland, Consolidated Rambler Mines Limited and the Buchans zinc-lead-silver mine, a joint venture of ASARCO Incorporated and The Price Company Limited, both had lower silver production in 1980. These mines have limited reserves.

Brunswick Mining and Smelting is one of the major byproduct silver producers in Canada. Production in 1980 was affected by a long labour strike that began on May 31 and was settled on September 25. Employees at the smelting division also went on strike on May 31 but returned to work on June 18 after reaching an agreement on a new contract. The expansion program to increase the mining and milling facilities to 10 000 tpd was delayed by the strike and is now expected to be completed in the first half of 1981. The overall silver recovery in 1980 was 59.8 per cent. Metallurgical test work is being carried out to improve silver recovery.



* As reported by Statistics Canada

1 As defined in Footnote 1 to Table 1.

2 Statistics for year 1960 to 1973 inclusive include consumption for coinage; 1974 to 1976 statistics include only partial consumption for coinage.

p Preliminary

Figure 2

Quebec. Silver output in Quebec, derived mostly as a byproduct from base-metal ores, was significantly lower in 1980 than the previous year mainly due to the closure of the Manitou Barvue division of Louvem Mining Company Inc., in 1979.

Selco Mining Corporation Limited and Hudson's Bay Oil and Gas Company Limited are bringing the "B" zone of Les Mines Selbaie project (formerly the Detour project), in northwestern Quebec, into production at a rate of 1 500 tpd. The mine is an underground operation and is scheduled to come on-stream in the second half of 1981. Cost of the project has been estimated at $80 million. Reserves are estimated to be 3.8 million t averaging 3.6 per cent copper, 0.5 per cent zinc and 31.8 g/t silver.

TABLE 4. PRINCIPAL SILVER (MINE) PRODUCERS - CANADA, 1980 AND (1979)

Company and Location	Mill Capacity (tonnes of ore/day)	Grade of Ore Milled: Silver (grams/ tonne)	Copper (%)	Lead (%)	Zinc (%)	Ore Milled (tonnes)	Silver contained in concentrates produced (kilograms)	Remarks
Newfoundland								
ASARCO Incorporated, Buchans	1 100 (1 100)	102.51 (109.71)	0.85 (1.04)	5.42 (6.51)	9.38 (11.64)	75 296 (113 398)	6 796 (11 036)	Limited reserves - Barite in tailings to be recovered.
Consolidated Rambler Mines Limited, Baie Verte	1 100 (1 100)	18.55 (23.52)	3.51 (3.90)	- (-)	0.67 (-)	164 281 (196 918)	2 286 (3 069)	Limited reserves.
New Brunswick								
Brunswick Mining and Smelting Corporation Limited, Nos. 12 and 6 mines combined Bathurst	9 050 (9 050)	97.37 (94.97)	0.31 (0.31)	3.56 (3.61)	8.80 (8.93)	1 848 036 (2 971 516)	127 782 (194 995)	Four month labour strike ended in September. Expansion program near completion.
Heath Steele Mines Limited, Newcastle	3 600 (3 600)	55.20 (55.20)	0.84 (0.91)	1.45 (1.53)	4.34 (4.55)	1 252 406 (1 172 737)	39 687 (37 933)	Noranda Mines Limited purchased 100 per cent ownership.
Quebec								
Campbell Resources Inc., Henderson and Cedar Bay, Chibougamau	3 650 (3 650)	6.86 (7.54)	0.99 (1.17)	- (-)	- (-)	390 981 (396 822)	1 645 (2 028)	
Corporation Falconbridge Copper, Lake Dufault Division, Corbet and Millenbach mines, Noranda	1 400 (1 400)	28.80 (48.69)	2.70 (3.60)	- (-)	2.19 (4.90)	475 464 (419 827)	10 132 (17 610)	Production commenced at Corbet mine.
Corporation Falconbridge Copper, Opemiska Division, Perry, Springer and Cooke mines, Chapais	2 900 (2 900)	10.29 (12.34)	1.57 (1.79)	- (-)	- (-)	964 052 (954 801)	8 046 (9 313)	
Gaspé Copper Mines, Limited, Needle Mountain and Copper Mountain mines, Murdochville	30 400 (30 400)	3.31 (3.16)	0.52 (0.51)	- (-)	- (-)	10 226 322 (5 635 594)	19 651 (10 510)	Drilling in Needle Mountain "C" northwest zone added to mineral inventory.

TABLE 4. (cont'd.)

Company and Location	Mill Capacity (tonnes of ore/day)	Grade of Ore Milled: Silver (grams/ tonne)	Copper (%)	Lead (%)	Zinc (%)	Ore Milled (tonnes)	Silver contained in concentrates produced (kilograms)	Remarks
Quebec (cont'd)								
Lemoine Mines Limited, (Patino, N.V.), Chibougamau	300 (300)	88.80 (92.91)	4.71 (5.07)	- (-)	10.00 (11.61)	104 326 (108 267)	8 082 (8 907)	Limited reserves.
Louvem Mining Company Inc., Louvicourt	900 (900)	30.38 (137.83)	0.15 (0.04)	0.11 (0.55)	3.89 (4.51)	224 530 (72 261)	3 196 (7 628)	Limited reserves.
Madeleine Mines Ltd., Murdochville	2 500 (2 500)	5.14 (6.86)	0.94 (0.98)	- (-)	- (-)	564 738 (297 853)	2 693 (1 502)	Carried out surface and underground exploration program.
Noranda Mines Limited, Mattagami Division, Matagami	3 500 (3 500)	21.39 (26.85)	0.77 (0.73)	.. (..)	4.81 (5.37)	1 328 360 (1 329 428)	15 189 (15 558)	Milled remaining ore from Radiore #2.
Patino Mines (Quebec) Limited, (Patino, N.V.) Chibougamau	2 700 (2 700)	9.22 (9.50)	1.68 (1.64)	- (-)	- (-)	615 035 (606 995)	3 842 (4 105)	Active exploration and ore development program.
Ontario								
Agnico-Eagle Mines Limited, Cobalt district	350 (350)	243.09 (156.69)	.. (..)	- (-)	- (-)	56 768 (41 799)	12 769 (5 827)	Exploration and development at Beaver-Temiskaming continuing.
Canadaka Mines Limited, Cobalt district	275 (275)	289.37 131.66	- (-)	- (-)	- (-)	22 220 (38 919)	6 037 (4 648)	
Corporation Falconbridge Copper, Sturgeon Lake Joint Venture, Sturgeon Lake	1 100 (1 100)	131.66 (169.71)	1.46 (2.17)	1.05 (1.23)	5.89 (8.70)	371 623 (373 953)	31 296 (52 721)	Closed in late 1980.
Falconbridge Nickel Mines Limited, Ontario Mines, Sudbury district	11 200 (11 200)	.. (..)	.. (..)	- (-)	- (-)	2 967 632 (2 083 770)	.. (..)	North mine brought back into production in mid-1980.

Inco Limited, Sudbury and Shebandowan, Ont., and Thompson, Man.	73 950 (73 950)	.. (..)	1.07 (1.02)	- (-)	- (-)	13 166 281 (7 608 907)	42 353[1] (23 414)[1]	Production ceased at Clarabelle open pit at the end of June 1980.
Mattabi Mines Limited, Sturgeon Lake	2 700 (2 700)	106.63 (97.71)	0.44 (0.55)	0.87 (0.77)	7.24 (6.91)	846 940 (945 015)	71 979 (73 085)	Lyon Lake Division mine began shipping to mill in October.
Noranda Mines Limited, Geco Division, Manitouwadge	4 550 (4 550)	60.69 (58.97)	1.47 (1.82)	0.14 (0.11)	3.32 (3.24)	1 358 317 (1 475 841)	60 976 (65 668)	Lower grade ore mined. Higher grade pillars being prepared for production.
Selco Mining Corporation Limited, South Bay Division Uchi Lake area	450 (450)	65.49 (63.77)	1.48 (1.44)	- (-)	8.79 (10.75)	117 290 (132 923)	5 954 (6 514)	Limited reserves, expected to close in 1981.
Teck Corporation, Silverfields Division, Cobalt district	250 (250)	171.43 (308.57)	0.60 (0.60)	- (-)	- (-)	76 041 (75 392)	11 992 (21 103)	
Texasgulf Canada Ltd., Kidd Creek mine, Timmins	9 050 (9 050)	86.36 (76.03)	1.83 (1.95)	0.85 (0.65)	5.78 (5.47)	3 899 575 (3 680 858)	291 387 (241 109)	Constructing copper smelter and preparing #2 mine for production.
Union Minière Explorations and Mining Corporation Limited, Thierry mine, Pickle Lake area	3 650 (3 650)	7.89 (8.23)	1.20 (1.15)	- (-)	- (-)	1 080 000 (956 291)	6 008 (5 482)	
Manitoba-Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited, Flin Flon mill, Flin Flon	7 250 (7 250)	19.78 (20.86)	1.67 (2.00)	0.15 (0.17)	2.11 (2.77)	945 379 (1 253 875)	12 119 (17 672)	Rod, Spruce Point and Trout Lake properties being developed.
Hudson Bay Mining and Smelting Co., Limited, Snow Lake mill, Snow Lake	3 450 (3 450)	16.66 (12.29)	2.65 (2.87)	0.23 (0.14)	3.23 (3.53)	756 283 (446 947)	8 819 (3 898)	
Inco Limited, Thompson	(Output included with company's listing for Ontario)							
Sherritt Gordon Mines Limited, Fox mine, Lynn Lake	2 600 (2 600)	.. (..)	1.40 (1.19)	- (-)	1.56 (1.82)	784 011 (772 500)		Production of silver for Ruttan and Fox mine: 15 521 kg in 1980, 12 623 kg in 1979.

TABLE 4. (cont'd)

Company and Location	Mill Capacity	Grade of Ore Milled Silver	 Copper	 Lead	 Zinc	Ore Milled	Silver contained in concentrates produced	Remarks
	(tonnes of ore/day)	(grams/ tonne)	(%)	(%)	(%)	(tonnes)	(kilograms)	
Manitoba-Saskatchewan (cont'd)								
Sherritt Gordon Mines Limited, Ruttan mine, Ruttan	9 050 (9 050)	.. (..)	1.36 (1.39)	- (-)	1.02 (1.17)	2 311 444 (2 094 159)		Mining of open pit ore completed.
British Columbia								
Afton Mines Ltd., Dominion pit, Kamloops	6 350 (6 350)	5.07 (4.90)	1.05 (1.06)	- (-)	- (-)	2 739 799 (2 822 528)	9 000 (9 242)	
Bethlehem Copper Corporation, Highland Valley	18 150 (18 150)	1.78 (..)	0.38 (0.41)	- (-)	- (-)	6 281 347 (6 536 861)	5 577 (6 957)	
Brenda Mines Ltd., Peachland	27 000 (27 000)	1.10 (..)	0.13 (0.14)	- (-)	- (-)	9 126 857 (9 075 720)	5 022 (5 752)	Fuel oil use at plant replaced by natural gas.
Cominco Ltd., Sullivan mine, Kimberley	9 075 (9 075)	44.57 (63.77)	- (-)	3.85 (5.33)	2.73 (3.73)	2 132 416 (2 047 726)	82 291 (117 131)	Major modifications of metallurgical plants at Trail and Sullivan mine at Kimberley.
Dankoe Mines Ltd., Keremeos	150 (150)	136.08 (250.29)	.. (..)	.. (..)	.. (..)	30 028 (25 536)	3 660 (6 088)	
DeKalb Mining Corporation, Highland Valley	650	20.19	1.93	-	-	48 234	866	Opened in mid-1980, former O.K. Alwin operation.
Dickenson Mines Limited, Silvana Division, Slocan district	100 (100)	295.89 (478.63)	- (-)	3.21 (4.87)	3.03 (4.51)	28 223 (19 625)	7 724 (8 996)	Amalgamated with Dickenson October 31, 1980.
Equity Silver Mines Limited, Houston	4 500	126.86	0.38	-	1.26	448 000	45 000	Production began in September.
Gibraltar Mines Limited, McLeese Lake	36 300 (36 300)	.. (..)	0.38 (0.42)	- (-)	- (-)	12 643 870 (10 446 035)	.. (..)	
Lornex Mining Corporation Ltd., Highland Valley	43 500 (43 500)	.. (..)	0.41 (0.42)	- (-)	- (-)	16 037 591 (16 126 103)	16 497 (17 625)	Expansion program underway will increase production by 68 per cent by 1981.

Newmont Mines Limited, Similkameen Division, Princeton	19 150 (19 150)	1.47 (1.20)	0.46 (0.44)	- (-)	- (-)	6 612 470 (7 034 952)	4 861 (4 155)	Developing Copper Mountain open pit.
Noranda Mines Limited, Granisle mine, Babine Lake	14 300 (14 300)	.. (..)	0.39 (0.45)	- (-)	- (-)	3 936 725 (4 382 909)	4 075 (5 154)e	
Northair Mines Ltd., Alta Lake	250 (250)	32.33 (26.33)	0.50 (0.50)	1.38 (0.91)	2.15 (1.50)	71 478 (91 587)	1 800 (2 020)	Exploration program to locate new reserves.
Teck Corporation, Beaverdell mine, Beaverdell	100 (100)	290.74 (320.23)	- (-)	0.23 (0.28)	0.56 (0.63)	38 550 (33 662)	8 979 (9 533)	
Utah Mines Ltd., Island Copper mine, Coal Harbour, Vancouver Island	34 450 (34 450)	.. (..)	0.42 (0.45)	- (-)	- (-)	13 757 175 (13 339 997)	12 409 (11 207)	
Wesfrob Mines Limited, Tasu Harbour, Queen Charlotte Islands	4 650 (4 650)	3.12 (4.46)	0.27 (0.37)	- (-)	- (-)	996 432 (1 009 247)	2 320 (3 346)	
Western Mines Limited, Buttle Lake, Vancouver Island	900 (900)	124.11 (131.31)	1.22 (1.32)	1.23 (1.37)	7.58 (8.45)	278 244 (266 877)	31 159 (31 074)	Preparatory work for sinking shaft on H-W zone.
Yukon Territory								
Cyprus Anvil Mining Corporation, Faro	9 050 (9 050)	47.01 (25.03)	- -	3.12 (3.26)	4.68 (5.28)	2 825 150 (2 823·031)	87 035 (61 494)	Changes being made in concentrator to cost $71.5; Grum and Vangorda mines being prepared for production.
Hudson Bay Mining and Smelting Co., Limited Whitehorse Copper Division, Whitehorse	2 250 (2 250)	10.29 (7.20)	1.58 (1.12)	- (-)	- (-)	775 013 (829 221)	7 360 (5 254)	
United Keno Hill Mines Limited, Elsa	450 (450)	787.20 (818.40)	- (-)	3.39 (3.00)	0.79 (-)	79 636 (112 783)	53 738 (78 931)	Labour strike began in early September.

TABLE 4. (cont'd)

Company and Location	Mill Capacity	Grade of Ore Milled				Ore Milled	Silver contained in concentrates produced	Remarks
		Silver	Copper	Lead	Zinc			
	(tonnes of ore/day)	(grams/ tonne)	(%)	(%)	(%)	(tonnes)	(kilograms)	
Northwest Territories								
Echo Bay Mines Ltd., Port Radium Great Bear Lake	100 (100)	1167.09 (1748.57)	0.81 (0.74)	- (-)	- (-)	36 076 (36 083)	41 253 (61 903)	
Nanisivik Mines Ltd., Strathcona Sound, Baffin Island	1 350 (1 350)	86.30 (66.17)	- (-)	2.37 (1.39)	14.28 (12.92)	435 147 (615 459)	30 936 (34 015)	
Terra Mining and Exploration Limited, Silver Bear mine and Norex Joint Venture Mine, Camsell River area Great Bear Lake	180 (180)	376.80 (421.71)	0.90 (1.03)	- (-)	- (-)	27 011 (31 020)	9 659 (12 471)	Actively engaged in exploratory work.

Source: Company reports and technical press.

[1] Silver delivered to market.
[e] Estimated; - Nil; .. Not available.

Ontario. Ontario is the largest silver producing province in Canada and will continue to be a major source in the future.

The leading silver producing mine in Canada is the copper-zinc-silver-lead Kidd Creek property of Texasgulf Canada Ltd. at Timmins. Silver contained in concentrates totalled 266 713 kg compared with 216 713 kg in 1979. Work continued on the $140 million mine-mill expansion program which will increase ore production to 4.5 million tpy, and on the $280 million copper smelter which has a designed capacity of 59 000 tpy. Both of these programs are expected to be completed in 1981. Included in the new copper refinery complex are plans for a silver refinery. According to Texasgulf, the proven and probable ore reserves at its Kidd Creek property at the end of 1980 are estimated to be 87.9 million t averaging 5.06 per cent zinc, 2.86 per cent copper, 0.18 per cent lead and 65.5 g/t silver.

The copper-zinc-lead mines in the Sturgeon Lake area of Ontario are substantial producers of silver. The Sturgeon Lake Joint Venture, managed by Corporation Falconbridge Copper, depleted its ore reserves and closed in the latter part of 1980. Mattabi Mines Limited, owned 60 per cent by Noranda Mines Limited and 40 per cent by Abitibi-Price Inc., is one of the larger silver producers in Canada. Silver production in 1980, which included some from Noranda's Lyon Lake division, was 63 862 kg. The company is carrying out an underground development program on the downward extension of the zone being mined by open-pit. Production from this area is expected to commence in mid-1981 and will replace ore from the open-pit mine which will be closed in 1981. The Lyon Lake property began production in October 1980 and is expected to reach a production rate of 1 000 tpd by March 1981. The ore is being treated at the Mattabi mill. Lyon Lake reserves are estimated to be 2.87 million t averaging 7.48 per cent zinc, 1.44 per cent copper, 0.73 per cent lead and 132.3 g/t silver. Also in the Sturgeon Lake area Noranda is preparing its open-pit "F" Group mine for production by mid-1981. The ore, which will be mined at the rate of about 650 tpd, will be treated at the Mattabi mill.

In the Cobalt district the silver-bearing ores are mined primarily for the recovery of silver. In 1980, silver output from the three producers was estimated to be 30 950 kg. Teck Corporation acquired an interest in the adjoining property of Consolidated Summit Mines Limited and will explore and develop this property by extending its present workings into Consolidated Summit's ground. Agnico-Eagle Mines Limited obtained ore from three mines in the Cobalt and Gowganda areas. The company is active in exploring and developing other silver properties in the area. Canadaka Mines Limited suspended operations at its properties at the end of the year. The silver-containing ores and concentrates produced in the Cobalt area are processed at the silver refinery of Canadian Smelting & Refining (1974) Limited at Cobalt. In mid-1980, Teck Corporation was granted a one year exemption from Section 113 of the Mining Act of Ontario, which states that all ores and minerals removed from Ontario lands shall be treated and refined in Canada, and was allowed to export its flotation concentrates for treatment. To improve the profitability of the silver operations in the Cobalt district, research is being done on the development of a process to economically recover the contained cobalt in the ores.

Manitoba-Saskatchewan. Most of the silver produced in Manitoba and Saskatchewan came from several base-metal mines operated by Hudson Bay Mining and Smelting Co., Limited near Flin Flon and in the Snow Lake district. Silver was also recovered from the Fox and Ruttan copper zinc mines operated by Sherritt Gordon Mines Limited at Lynn Lake and Ruttan, respectively.

British Columbia. Base-metal ores continued to be the main source of British Columbia's mine output of silver. Cominco Ltd., the largest silver producer in the province, derived its output from the lead-zinc-silver ores of its Sullivan mine and from purchased ores and concentrates. Production of silver at the Sullivan mine in 1980 was 94 477 kg, down substantially from the 126 240 kg produced in 1979 because of high dilution and the treatment of lower grade open-pit ore. Cominco's total silver production from all sources in 1980 was 277 350 kg compared with 311 097 kg in 1979.

Production of an unleached concentrate began on October 1 at the Sam Goosly silver-copper mine of Equity Silver Mines Limited, 37 km south of Houston in north-central British Columbia. Placer Development Limited has a 70 per cent interest in Equity Silver and also manages the property.

Designed capacity of the concentrator is 4 500 tpd but in 1980 the concentrator operated at a rate of 5 000 tpd. The construction of a leach plant, which is required to remove impurities from the concentrate to produce a readily marketable product, is expected to be completed by mid-1981. Addition of the leach plant has substantially increased capital expenditures in developing the property and the overall cost is now expected to be about $129 million. The unleached concentrates are being shipped to Japan but because of environmental problems in treating the concentrates the smelters are able to handle only a portion of the mine output. Concentrates were therefore stockpiled for treatment at a later date. Equity Silver signed a three year contract with two Japanese companies, Dowa Mining Co. Ltd. and Sumitomo Corporation to purchase the leached concentrates. Ore is mined by open pit methods from the Southern Tail Zone, where ore reserves are estimated to be 6.8 million t averaging 131 g/t silver and 1.38 g/t gold, 0.48 per cent copper and some antimony. A second zone, the Main Zone, will be mined later. Overall ore reserves have been estimated at 27 million t averaging 104.3 g/t silver and 0.38 per cent copper. At full production, Equity will be one of the major producers in Canada.

In October, Dickenson Mines Limited and Silvana Mines Inc. amalgamated to form Dickenson Mines Limited, Silvana Mines becoming a division of Dickenson Mines. Silvana is similar to Dankoe Mines Ltd. and Teck Corporation (Beaverdell) in that all are principally silver mines. The overall production of these mines was small and their geological characteristics make it difficult to develop large proven ore reserves.

Yukon Territory. Mine production of silver in the Yukon in 1980 was slightly lower than in 1979. Lower production from United Keno Hill Mines Limited because of a labour strike was partly offset by increased output from Cyprus Anvil Mining Corporation.

Members of the United Steel Workers of America commenced a legal strike on September 10, 1980 at the operations of United Keno, Elsa, and it was still in effect at year-end. This company is one of the major silver producers in Canada. Exploration and development work in 1980 was successful in increasing reserve tonnage by 45 per cent to 435 800 t but grade declined by 15 per cent to 847 g/t of silver.

On December 31, 1978 United Keno Hill optioned the former producing silver-gold-base metal Venus Mine, near Carcross, Yukon. Following an appraisal of the property the company decided to bring the mine into production at a rate of 90 tpd. Production is scheduled for the latter part of 1981. Reserves are estimated to be 108 000 t averaging 226 g/t silver and 7.5 g/t gold.

Northwest Territories. Silver production declined sharply in 1980 because the two silver producers at Great Bear Lake, Echo Bay Mines Ltd. and Terra Mining and Exploration Limited, both reported lower output. The erratic nature and generally narrow widths of the ore zones in the Great Bear Lake deposits make it difficult to build up reserves and as a result grade of ore treated can vary considerably from year to year.

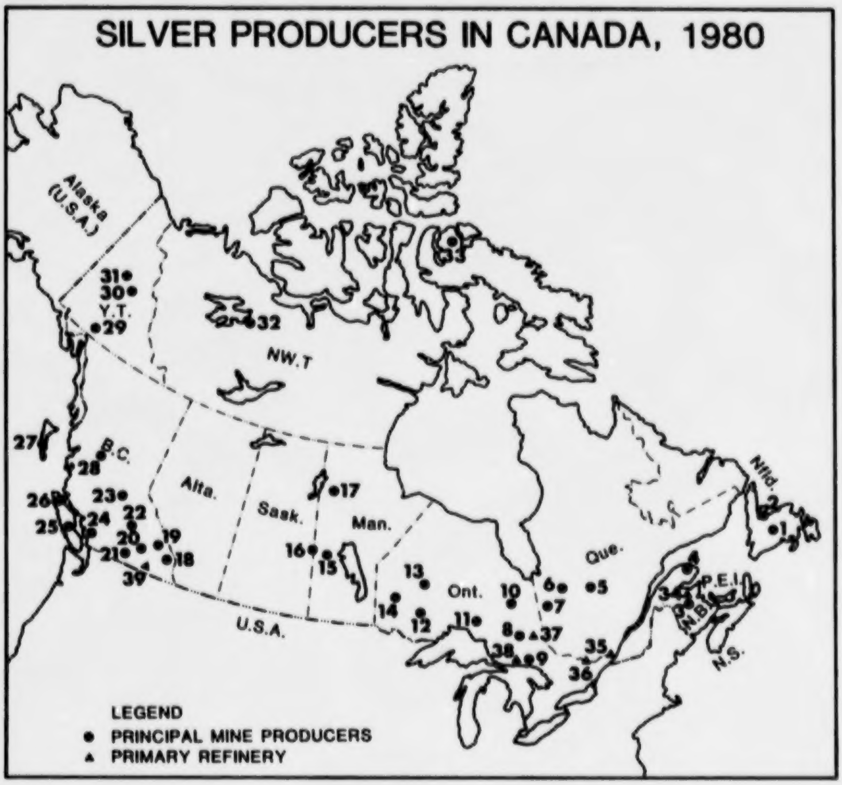
Cadillac Explorations Limited expects to bring its silver-lead-zinc mine in production in 1982 at an estimated cost of $32 million. The property is located about 340 km north of Fort Nelson, British Columbia, at Prairie Creek, a tributary of the South Nahanni River. Plant equipment, including a 900 tpd mill, will be hauled to the property over a winter road in 1980-81. Work is also under way on underground development. Reserves have been reported at about 1.36 million t averaging 171 g/t silver, 11 per cent lead, 12 per cent zinc and 0.4 per cent copper.

WORLD PRODUCTION, CONSUMPTION AND ECONOMIC FACTORS

New production of silver in the noncommunist world in 1980, as estimated by The Silver Institute of Washington, D.C., was 7 850 t, approximately 4.7 per cent below the 8 236 t produced in 1979. Production of silver in the eastern bloc countries in 1980 was estimated to be 2 448 t compared with 2 501 t in 1979.

Based on preliminary data, Canada was the fourth largest mine producer in 1980, being surpassed by U.S.S.R., Mexico and Peru. United States production was slightly below that of Canada. These five countries accounted for about 60 per cent of the world's total primary silver production.

In 1980, non-communist world consumption of silver for both industrial and coinage uses, as estimated by Handy &



SILVER PRODUCERS IN CANADA, 1980

Alaska (U.S.A.)
Y.T.
NW.T
B.C.
Alta.
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
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LEGEND
● PRINCIPAL MINE PRODUCERS
▲ PRIMARY REFINERY

Principal mine producers
(numbers refer to numbers on map above)

1. ASARCO Incorporated (Buchans Unit)
2. Consolidated Rambler
   Mines Limited
3. Brunswick Mining and Smelting
   Corporation Limited,
   (Nos. 12 and 6 mines)
   Heath Steele Mines Limited
4. Gaspé Copper Mines, Limited
   Madeleine Mines Ltd.
5. Campbell Resources Inc.
   Corporation Falconbridge Copper,
   Opemiska Division
   Lemoine Mines Limited
   Patino Mines (Quebec) Limited
   Patino, N.V.
6. Noranda Mines Limited,
   Matagami Division
7. Corporation Falconbridge Copper,
   Lake Dufault Division
8. Agnico-Eagle Mines Limited
   Canadaka Mines Limited
   Teck Corporation,
   Silverfields Division
9. Falconbridge Nickel Mines Limited
   Inco Limited
10. Texasgulf Canada Ltd.,
    Kidd Creek mine
11. Noranda Mines Limited,
    Geco Division
12. Corporation Falconbridge Copper[1],
    Sturgeon Lake Joint Venture
    Mattabi Mines Limited
    Noranda Mines Limited,
    Lyon Lake Division[2]
13. Union Minière Explorations and Mining
    Corporation Limited,
    Thierry mine

14. Selco Mining Corporation Limited,
South Bay Division
15. Hudson Bay Mining and Smelting Co., Limited,
Snow Lake area (Anderson Lake, Chisel Lake, Ghost Lake, Osborne Lake and Stall Lake mines)
16. Hudson Bay Mining and Smelting Co., Limited,
Flin Flon area (Centennial, Flin Flon, Westarm and White Lake mines)
17. Sherritt Gordon Mines Limited,
Fox & Ruttan Mines
18. Cominco Ltd. (Sullivan mine)
19. Dickenson Mines Limited,
Silvana Division
(Silmonac mine)
20. Brenda Mines Ltd.
Similkameen Mining Company Limited
21. Dankoe Mines Ltd.
Teck Corporation,
Beaverdell mine
22. Afton Mines Ltd.
Bethlehem Copper Corporation
Lornex Mining Corporation Ltd.
23. Gibraltar Mines Limited
24. Northair Mines Ltd.
25. Western Mines Limited
26. Utah Mines Ltd.,
Island Copper Mine
27. Wesfrob Mines Limited
28. Equity Silver Mines Limited[2]
Noranda Mines Limited,
Granisle mine
29. Hudson Bay Mining and Smelting Co., Limited,
Whitehorse Copper Division
30. Cyprus Anvil Mining Corporation
31. United Keno Hill Mines Limited
32. Echo Bay Mines Ltd.
Terra Mining and Exploration Limited
33. Nanisvik Mines Ltd.

Primary refineries

(numbers refer to numbers on the map)

34. Brunswick Mining and Smelting Corporation Limited, Smelting Division
35. Canadian Copper Refineries Limited
36. Royal Canadian Mint
37. Canadian Smelting & Refining (1974) Limited
38. Inco Limited
39. Cominco Ltd.

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[1] Closed in 1980; [2] Opened in 1980.

Harman[1], was 11 069.7 t compared with 13 921.9 t in 1979. The gap between primary production and consumption in 1980 was 3 218.7 t compared with 5 685.9 t in 1979.

Substantial amounts of silver were consumed in the coinage sector of the silver industry. The Silver Institute, in its publication **Modern Silver Coinage 1980**, reported that silver used in official coins was 429 468 kg compared with 759 313 kg in 1979. The leading consumers of silver in coinage in 1980 and the amounts used were: Mexico 157 259 kg, U.S.S.R. 67 495 kg, Austria 65 275 kg, Venezuela 17 550 kg and Italy 16 248 kg. These six countries accounted for 79 per cent of the total silver usage in coinage. All silver used by Mexico was in the minting of 5,056,000 "bullion coins" (onza troy) which contain one troy ounce of fine silver. The onza troy coin does not carry a currency denomination but has a mark stating it contains one troy ounce of silver.

To commemorate the 1980 Olympics held in Moscow, the U.S.S.R. issued a number of legal tender silver, gold and platinum coins. In the silver coin program 28 different coins were issued. Fourteen of these coins had a face value of five rubles each, weighed 16.67 g and contained 15 g of silver. The remaining 14 coins had a face value of 10 rubles each, weighed 33 g and contained 30 g of silver. It was planned to mint a maximum of 450,000 of each of these coins.

According to the Silver Institute, new production of silver in the United States in 1980 was 945.6 t, 20.1 per cent lower than the 1 183.6 t produced in 1979. In the U.S., the world's largest silver consumer, consumption for industrial purposes declined by 25 per cent to 3 878.4 t from the 4 891.3 t consumed in 1979. Silver used in coinage was 2.24 t in 1980 compared with 5.23 t in 1979. The large difference between primary production and consumption

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[1] The **Silver Market 1980**, compiled by Handy & Harman, a leading United States refiner and fabricator of precious metals and large consumer of silver.

TABLE 5. WORLD MINE PRODUCTION OF SILVER, 1979 AND 1980

	1979[1]		1980[1]P	
	(troy ounces)	(kilograms)	(troy ounces)	(kilograms)
U.S.S.R.	49,800,000^e	1 548 900^e	49,900,000^e	1 552 100^e
Mexico	49,400,000	1 536 500	47,100,000	1 465 000
Peru	40,200,000	1 250 400	39,600,000	1 231 700
Canada	36,900,000	1 147 700	33,300,000	1 035 800
United States	38,100,000	1 185 000	30,400,000	945 500
Australia	24,800,000	771 400	23,500,000	730 900
Poland	22,600,000^e	702 900^e	20,900,000^e	650 100^e
Chile	8,700,000	270 600	9,600,000	298 600
Japan	8,900,000	276 800	8,900,000	276 800
Republic of South Africa	3,200,000	99 500	7,100,000	220 800
Bolivia	5,700,000	177 300	6,200,000	192 800
Sweden	5,700,000	177 300	5,100,000	158 600
Yugoslavia	5,200,000	161 700	4,800,000	149 300
Zaire	3,900,000	121 300	4,000,000	124 400
Spain	3,400,000	105 800	3,300,000	102 600
Morocco	2,400,000	74 700	2,700,000	84 000
France	2,400,000	74 700	2,400,000	74 700
South Korea	2,800,000	87 100	2,300,000	71 500
Argentina	2,200,000	68 400	2,200,000	68 400
Philippines	1,800,000	56 000	2,000,000	62 200
People's Republic of China	2,000,000^e	62 200^e	1,900,000^e	59 100^e
Greece	1,700,000	52 900	1,800,000	56 100
Honduras	1,900,000	59 100	1,600,000	49 800
Dominican Republic	2,300,000	71 500	1,600,000	49 800
North Korea	1,500,000^e	46 700^e	1,600,000^e	49 800^e
Namibia	1,600,000	49 800	1,500,000	46 700
East Germany	1,500,000	46 700	1,500,000	46 700
Papua New Guinea	1,400,000	43 500	1,200,000	37 300
Italy	1,100,000	34 200	1,100,000	34 200
West Germany	1,000,000	31 100	1,100,000	34 200
Czechoslovakia	1,100,000^e	34 200^e	1,100,000^e	34 200^e
Zimbabwe	1,000,000	31 100	1,000,000	31 100
Finland	800,000	24 900	900,000	28 000
Other countries	8,200,000	255 000	7,900,000	245 700
Total	345,200,000	10 736 900	331,100,000	10 298 400

Sources: Energy, Mines and Resources Canada; The Silver Institute, Washington, D.C.
[1] Figures represent mine production of silver on an accountable basis.
P Preliminary; ^{e} Estimated.

was met by imports, demonetized coinage, secondary silver derived from discarded jewellery, silverware and films, and withdrawals from existing stocks. Most of the requirements for United States coinage were obtained from Treasury stocks held by the Bureau of Mint, which declined slightly during 1980 to 1 209.6 t from 1 212.7 t in 1979. In 1976 the U.S. Federal Preparedness Agency (FPA) declared the 4 338.9 t of silver contained in the nation's strategic and critical stockpile to be surplus to the country's requirements but this silver cannot be disposed of without receiving Congressional approval. However, bills introduced in Congress for this purpose have not received the necessary consensus.

Japan is the non-communist world's second-largest consumer of silver. Silver consumption in 1980 amounted to 1 919.1 t compared with 2 136.8 t in 1979. The photographic industry in Japan consumed about 989.1 t, 51.5 per cent of the total. This was only slightly lower than the 1 000.1 t consumed in 1979.

TABLE 6. UNITED STATES CONSUMPTION OF SILVER BY END-USE[1], 1979 AND 1980

	1979[2]		1980[2]	
	(kilograms)[3]	(%)	(kilograms)[3]	(%)
Electroplated ware	250 850	5.1	135 300	3.5
Sterling ware	407 082	8.3	282 482	7.3
Jewellery	166 653	3.4	183 293	4.7
Photographic materials	2 052 145	42.0	1 549 731	40.0
Dental and medical supplies	71 383	1.5	68 801	1.8
Mirrors	57 542	1.2	20 902	0.5
Brazing alloys and solders	339 401	6.9	264 628	6.8
Electrical and electronic products:				
Batteries	142 547	2.9	185 874	4.8
Contacts and conductors	1 042 153	21.3	864 552	22.3
Bearings	10 326	0.2	20 186	0.5
Catalysts	175 330	3.6	94 399	2.4
Coins, medallions and commemorative objects	145 440	3.0	145 969	3.8
Miscellaneous[4]	30 419	0.6	62 300	1.6
Total net industrial consumption	4 891 271	100.0	3 878 417	100.0
Coinage	5 225		2 239	
Total consumption	4 896 496		3 880 656	

Sources: United States Department of the Interior, Bureau of Mines, **Mineral Industry Surveys**, "Gold and Silver in December 1980" for 1979 statistics and "Gold and Silver in June 1981" for 1980 statistics.

[1] End-use as reported by converters of refined silver. [2] Final figures; includes companies reporting annually. [3] Statistics originally reported in troy ounces have been converted to kilograms. [4] Includes silver-bearing copper, silver-bearing lead anodes, ceramic paints, etc.

Industrial consumption of silver in West Germany in 1980 was about 905.1 t, a decrease of 22 per cent from 1979.

On the New York Commodity Exchange (Comex), one of the principal futures markets for contracts in silver in the United States, the trading volume in silver in 1980 amounted to just over one million contracts of 5,000 troy ounces each compared with over 4 million contracts in 1979. The volume of silver traded on the Chicago Board of Trade in 1980 amounted to 341 000 contracts of 5,000 troy ounces each compared with 2.72 million contracts in 1979. Trading volume on the MidAmerican Commodity Exchange at Chicago was 209 000 contracts of 1,000 troy ounces each compared with 362 000 contracts in 1979. Silver traded on the London Metal Exchange was 434.24 million troy ounces in 1980 compared with 585.94 million troy ounces in 1979.

Comex silver stocks at the end of 1980 were 86.65 million ounces compared with 74.81 million ounces at the end of 1979. Chicago Board of Trade silver in storage at the end of 1980 and registered for delivery against futures contracts was 34.15 million ounces compared with 58.32 million ounces in 1979. Both figures for the Chicago Exchange exclude some additional silver that may have been in stocks but not registered for future delivery. London Metal Exchange silver stocks at the end of 1980 were 26.85 million troy ounces compared with 13.10 million troy ounces at the end of 1979. United States industrial stocks on hand December 31, 1980 were reported to be some 30.31 million ounces compared with 16.10 million ounces at the end of 1979.

The U.S.S.R. was the world's largest silver producer in 1980. Output was estimated at 1 552 t compared with 1 549 t in 1979. Most of the silver is recovered as a

TABLE 7. NON-COMMUNIST WORLD CONSUMPTION OF SILVER, 1979 AND 1980

	1979		1980P	
	(troy ounces)	(kilograms)	(troy ounces)	(kilograms)
Industrial uses				
United States	157,200,000	4 889 467	119,700,000	3 723 086
Japan	68,700,000	2 136 809	61,700,000	1 919 085
West Germany	37,100,000	1 153 939	29,100,000	905 111
Italy	33,000,000	1 026 415	24,500,000	762 035
United Kingdom	26,500,000	824 242	20,500,000	637 621
France	21,500,000	668 725	20,200,000	628 290
India	19,000,000	590 966	16,000,000	497 656
Belgium	16,800,000	522 538	15,700,000	488 325
Canada	8,100,000	251 938	6,800,000	211 504
Mexico	5,500,000	171 069	3,500,000	108 862
Other countries	26,400,000	821 132	22,500,000	699 828
Total industrial uses	419,800,000	13 057 240	340,200,000	10 581 403
Coinage				
Mexico	5,000,000	155 517	5,100,000	158 628
Austria	5,000,000	155 517	4,300,000	133 745
Canada	300,000	9 331	200,000	6 220
United States	100,000	3 110	100,000	3 110
France	7,700,000	239 497	-	-
West Germany	3,700,000	115 083	-	-
Other countries	6,000,000	186 621	6,000,000	186 621
Total coinage	27,800,000	864 676	15,700,000	488 324
Total consumption	447,600,000	13 921 916	355,900,000	11 069 727

Source: Handy & Harman, **The Silver Market, 1980.**
P Preliminary; - Nil.

byproduct from lead-zinc-copper mines. Output of base-metal ores is increasing at a low rate and production of silver from the U.S.S.R. is not expected to rise significantly in the next few years.

Mexico is a major world producer of silver, being surpassed by a small margin by the U.S.S.R. in 1980. Production in 1980 was estimated at 1 465 t compared with 1 537 t in 1979. The recent sharp rise in the silver price has led to expansion programs at some producing mines. Also, some mining companies have decided to bring new silver properties into production. Exploratory work has increased and some Canadian companies are involved in this activity.

Initiated by the dramatic increase in the gold and silver prices in late 1979 and early 1980, the Mexican government introduced a "windfall profit" tax on gold and silver sales, effective January 26, 1980. The tax initially was 40 per cent of sales revenues above a specified price based on production costs plus a reasonable profit and adjusted on a monthly basis. The initial base price was set at approximately $US 8 per ounce for silver and $US 237.50 an ounce for gold.

Following representation from the Mexican mining community and the sharp drop in precious metal prices from their January 1980 highs, the Mexican government in April introduced a sliding scale base whereby no tax was payable when the price of silver was below $US 17.14 a troy ounce while the tax rose in six increments from 6 per cent at a price of $18.15 to 40 per cent at $23.20. In August, mining companies with annual sales of less than 36 million pesos (approximately $Cdn 1.76 million) were exempted from the tax while those with sales ranging from 36 million to 250 million pesos were made subject to half the sliding tax scale set in April 1980.

Minera Real de Angeles, S.A. de C.V., a Mexican company in which Placer Development Limited of Vancouver has a 34 per cent interest, began development of a silver-lead-zinc open-pit mine in the state of Zacatecos early in 1980. Production is expected to begin in 1982. Other partners in the project are the Mexican government, through the Comission de Fomento Minero, and a major Mexican mining company, Minera Frisco S.A. de C.V., each with a 33 per cent interest. Designed capacity of the concentrator is 10 000 tpd and the overall cost of the project has been estimated at $US 150 million. Annual production is expected to be 225 000 kg of silver, 32 000 t of lead and 26 000 t of zinc. At full production this mine will be one of the world's major silver producers. Ore reserves have been estimated at 59 million t averaging 73 g/t silver, 1.0 per cent lead and 0.9 per cent zinc.

Lacana Mining Corporation, of Toronto, is actively involved in silver mining in Mexico. The company has a 30 per cent interest in Compania Minera Las Torres, S.A. which operates four underground silver-gold mines near Guanajuato in central Mexico. Other partners in the venture are two of Mexico's important mining companies, Cia. Fresnillo, S.A. and Industrias Penoles, S.A. de C.V. The ores from these mines are treated at a 2 000 tpd flotation concentrator. Production in 1980 was 134 336 kg of silver, about 14 per cent lower than in 1979 because higher silver prices made the mining of lower grade ore possible. Gold production was 1 038 kg.

Lacana also has a 40 per cent interest in the La Encantada Mining Group, a silver-lead property in the State of Coahuila. The remaining 60 per cent is held by Industrias Penoles. The Encantada Group consists of three contiguous mines which supply ore to a centrally located 1 200 tpd flotation plant. Production in 1980 was 35 785 kg.

Avino Mines & Resources Limited, of Vancouver, has a 49 per cent interest in Cia Minera Mexicana de Avino S.A., an open-pit silver property in the State of Durango. A new concentrator is being constructed that will initially treat 600 tpd but will be increased later to 1 200 tpd. The present concentrator can handle 450 tpd. Other Canadian companies are involved in exploratory work in Mexico.

Industrias Penoles, one of Mexico's major mining companies, is the largest Mexican producer of refined silver, accounting for over 60 per cent of the total. Its annual refinery capacity is rated at 1 430 700 kg. The other major producer of refined silver in Mexico is Industrial Minera Mexico S.A.

Through its purchase of Rosario Resources Corporation, AMAX Inc. acquired several silver producers in Mexico, the main ones being Compania Fresnillo, S.A. and Zimapan S.A. in which Rosario has a 40 per cent interest. In 1980, these companies produced 211 504 kg of silver. At Cuale, in the State of Jalisco, the Fresnillo Group is bringing its open-pit silver-lead-zinc mine into production at a rate of 1 000 tpd. Production is expected to begin early in 1981.

In 1980 the El Mochito mine of Rosario Resources in Honduras produced 53 529 kg of silver plus lead and zinc concentrates. The concentrator is being expanded from its current level of 1 000 tpd to 2 300 tpd, with completion expected in 1983.

Peru is a major producer of silver and in 1980 ranked third in the world's silver producing countries. Silver output was 1 231.7 t compared with 1 250.4 t in 1979. Empresa Minera del Centro del Peru S.A. (CENTROMIN - PERU), a government company, is the largest producer, accounting for over 60 per cent of the total. Expansion programs under way are expected to increase CENTROMIN's silver output by about 14 per cent by 1983.

In Chile, Compania Minera San Jose, Inc., a subsidiary of St. Joe Minerals Corporation of New York, is bringing its 80 per cent controlled El Indio gold-silver-copper mine into production at a rated capacity of 1 270 tpd. The property is about 500 kilometres (km) northeast of Santiago. The plant is expected to be in operation in 1981. Reserves are estimated at 2.9 million t averaging 168 g/t silver, 17 g/t gold and 3 per cent copper. High grade gold ore shipments are being made and in 1980 these shipments contained 2 893 kg of gold plus some silver.

In 1980, silver production in the United States was affected by two major labour disputes. Some 40,000 copper miners went on strike on June 30 when the United Steelworkers Union and the copper producing companies were unable to agree on a new three-year contract, halting production at the major United States copper mines. The copper mines are substantial producers of byproduct silver. Settlements with some of the producers began in September and all disputes were settled by the end of 1980.

In early November the employees at the Idaho mine of Sunshine Mining Company reached an agreement with the company on a 41-month contract after a strike which began on March 15, 1980. Sunshine is one of the major producers of primary silver in the United States. The company is constructing a $6 million leach and electrowinning silver refinery at its Kellogg, Idaho smelter. Capacity will be about 5 million ounces of silver per year with completion expected in the latter part of 1981. Sunshine's concentrates are currently being refined by ASARCO Incorporated. Sunshine plans to bring its 16-to-1 silver mine near Silver Peak, Nevada into production by 1982 at an estimated cost of $18 million. It is estimated that annual production will be about 31 103 kg of silver.

ASARCO, through its mines in the United States and its equity in other silver-producing properties throughout the world, is one of the world's largest mine producers of silver. It operates two major silver mines in the Coeur d'Alene district of Idaho, the Galena and Coeur mines. The tonnage of ore treated at both these mines increased in 1980 but silver production was lower at the Galena mine, the largest single producer of primary silver in the United States, because the higher silver price in 1980 made it economical to treat lower grade ore. The strike at the company's United States copper mines lowered silver recovered as a by-product from copper ores. Production of refined silver by ASARCO in 1980 was 841 567 kg, which was 281 300 kg lower than 1979 output, largely because its Amarillo, Texas copper refinery, where silver is refined, was closed because of the strike. New facilities, which are scheduled for completion in 1981, are being installed at the Amarillo plant to handle scrap containing precious metals.

Construction and underground work continued at ASARCO's Troy mine in western Montana and it is expected that the mine will be in operation by mid-1981. The cost of the project has been estimated at $82.6 million. Ore reserves are estimated to be 50 million t averaging 52.8 g/t silver and 0.74 per cent copper. ASARCO estimates annual capacity of the plant at 130 635 kg of silver and 18 100 t of copper.

In February 1980, Hecla Mining Company awarded a construction contract to J.S. Redpath Corporation of Arizona, an affiliate of J.S. Redpath Limited of Toronto, to sink a new 2 286 m shaft at its Lucky Friday mine in Coeur d'Alene district of Idaho. It will provide access to the ore below the 1 524 m level and on completion will allow a 35 per cent increase in production. In 1980, Hecla's share of silver output from the four United States mines in which the company has an interest was 107 605 kg.

AMAX Inc. acquired Rosario Resources Corporation in April 1980 and merged it into a wholly owned subsidiary. Rosario Resources owns and operates silver-lead-zinc mines in Honduras and Mexico and has interests in oil and gas in Canada.

Australia is the world's sixth-largest producer of silver, mostly as a byproduct or coproduct of base-metal ores. Silver produced in 1980 was approximately 730 900 kg, about 6 per cent lower than in 1979. New mines coming into production and expansions at producing mines should substantially increase Australia's silver production in the next few years.

Mount Isa Mines Ltd. (owned by M-I-M Holdings Ltd.) in Queensland is the world's largest silver producer. The company produced approximately 456 000 kg in the year ending June 30, 1980, over 60 per cent of Australia's total output. Production at Mount Isa's lead-zinc-silver mine is to be increased by 20 per cent by 1982-83. Reserves of primary ore are estimated to be 56 million t averaging 150 g/t silver, 6.4 per cent lead and 6.5 per cent zinc. M-I-M and Seltrust Mining Corp. Pty. Ltd., formed a joint venture with 40 per cent and 60 per cent interest respectively, to bring the copper-zinc-lead-silver Teutonic Bore Project, in Western Australia, into production early in 1981 at a rate of 800 tpd. Ore will come initially from an open-pit and later from an underground operation. Ore reserves are estimated to be 2.5 million t averaging 150 g/t silver, 3.5 per cent copper, 9.5 per cent zinc and 0.8 per cent lead.

Australian Mining & Smelting Limited (AM&S), a wholly-owned subsidiary of CRA Ltd. (formerly Conzinc Riotinto of Australia Limited), operates two lead-zinc-silver mines near Broken Hill, New South Wales. The company is a large Australian silver producer. A major exploration program is to be undertaken by AM&S in the Broken Hill district to locate additional deposits of lead-zinc-silver to ensure continuing operations in the area. The company also has a one third interest in the Woodlawn zinc-lead-copper-silver mine in New South Wales. This mine opened in 1978 and experienced metallurgical problems but changes to the plant improved metal recoveries in 1980. The Woodlawn mine is also owned one third each by subsidiaries of Phelps Dodge Corporation and St. Joe Minerals Corporation, both of the United States. Reserves are estimated to be 6.5 million t averaging 47.3 g/t silver, 9.4 per cent zinc, 3.3 per cent lead and 1.8 per cent copper.

Electrolytic Zinc Company of Australasia Ltd. is bringing its Elura silver-lead-zinc mine, near Cobar, New South Wales, into production. The contract for the project was awarded to Fluor Australia Pty. Limited, a subsidiary of Fluor Corporation of the United States. The project will cost an estimated $A160 million and will comprise the development of an underground mine and a 3 000 tpd concentrator. Completion is expected late in 1982. The deposit is estimated to contain 27 million t averaging 139 g/t silver, 8.3 per cent zinc and 5.6 per cent lead.

Aberfoyle Limited, in which Cominco Australian Pty. Ltd., a wholly owned subsidiary of Cominco Ltd., has a 45 per cent interest, is bringing its Que River lead-zinc-silver mine in Tasmania into production. The ore will be treated at the Tasmanian concentrator of Electrolytic Zinc. The mine is scheduled to come on-stream in early 1981 at an annual rate of 150 000 to 200 000 t.

In the Republic of South Africa, Black Mountain Mineral Development Company Limited brought its Broken Hill lead-zinc-copper-silver mine in northwestern Cape Province into production in late 1979. The capacity of the concentrator is rated at approximately 3 000 tpd. Total cost to develop the property was about $201 million, slightly below the feasibility study estimate. The company is one of the world's major silver producers and in 1980, the first full year of operation, production was about 135 922 kg. Ore reserves have been estimated at 34.5 million t averaging 85 g/t silver, 6.35 per cent lead, 2.85 per cent zinc and 0.45 per cent copper. Phelps Dodge Corporation of the United States holds 49 per cent of the shares and Gold Fields of South Africa Ltd. holds the remaining 51 per cent.

USES

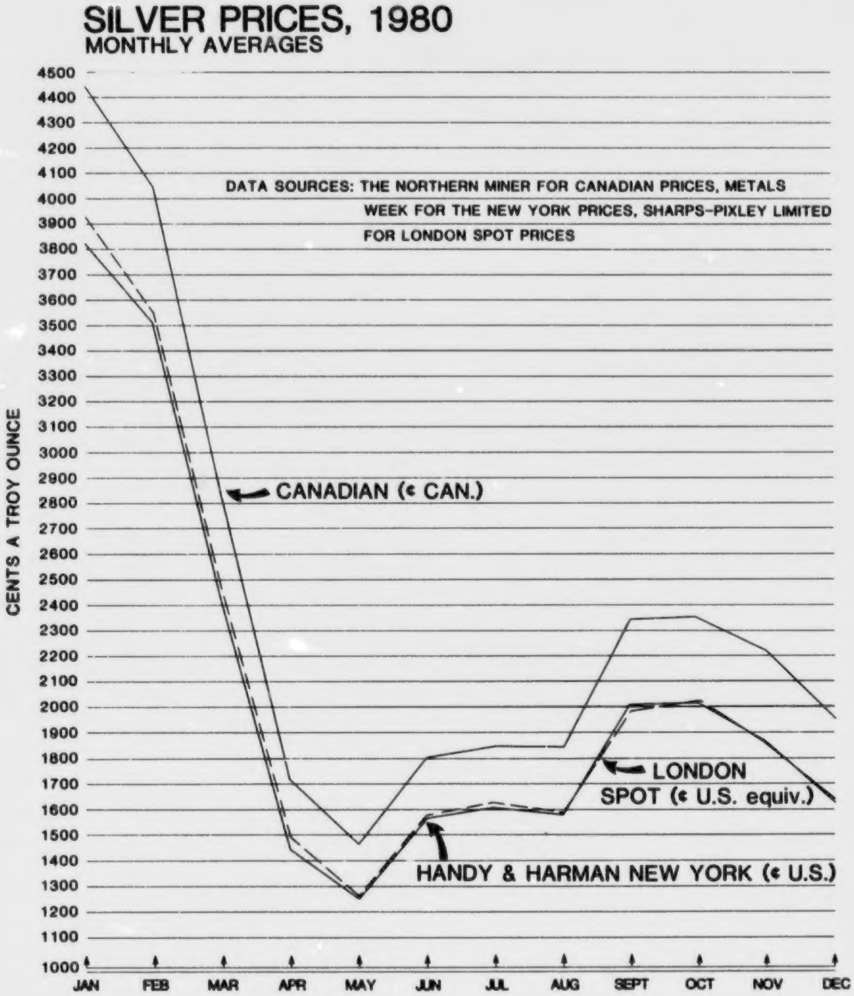
There was no marked change in the pattern of silver usage in industrial applications in 1979 from the previous year, despite the large increase in average prices. The major uses of silver are the photographic industry, electric and electronic industries, sterling ware, electroplate ware, brazing alloys and solders. In 1979, silver emerged as an important metal in the speculative field, as a hedge against inflation and in hoarding. Speculation will continue to be a major factor in determining silver price and in the amount of silver removed or made available to the market.

Silver is used in a myriad of applications and research is going on continuously for new uses. The silver chapter of the Canadian Minerals Yearbook 1977 detailed the many uses of silver.

PRICES

Silver prices fluctuated widely in 1980 on world markets. The phenomenal silver price increase that took place in 1979 continued into 1980, reaching an all-time high of $US 48 an ounce of silver on January 21 as quoted by Handy & Harman of New York. This was an increase of $20 per ounce over the closing 1979 price. Unsettled world conditions, both economically and politically, were partly responsible for the silver price surge but the main cause was excessive speculation on the commodity futures market. Trading restrictions on the New York Commodity Exchange on January 21 halted the upward speculative pattern and the silver price fell sharply to $34 an ounce by the end of January.

The silver price remained stable for the month of February and the first part of March but the high price brought out large amounts of silver coins and scrap from private sources and this silver had an important bearing on lowering the silver price. On March 27 the market collapsed, reportedly when major speculators could not meet margin requirements on futures contracts. Brokerage firms were forced to liquidate part of customers' collateral to meet financial obligations. At this time the price quoted by Handy & Harman declined to a low of $11.10 an ounce.


SILVER PRICES, 1980
MONTHLY AVERAGES
CENTS A TROY OUNCE
4500
4400
4300
4200
4100
4000
3900
3800
3700
3600
3500
3400
3300
3200
3100
3000
2900
2800
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
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1400
1300
1200
1100
1000
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEPT
OCT
NOV
DEC
DATA SOURCES: THE NORTHERN MINER FOR CANADIAN PRICES, METALS WEEK FOR THE NEW YORK PRICES, SHARPS-PIXLEY LIMITED FOR LONDON SPOT PRICES
CANADIAN (¢ CAN.)
LONDON SPOT (¢ U.S. equiv.)
HANDY & HARMAN NEW YORK (¢ U.S.)

Figure 4

TABLE 8. ANNUAL AVERAGE SILVER PRICES: CANADA, UNITED STATES AND UNITED KINGDOM, 1971-80

		United States	United Kingdom	
	Canada	Handy & Harman, New York	London Spot	London Spot
	($Cdn)	($US)	(pence)[2]	($US equiv.)[3]
		(per troy ounce)		
1971	1.571	1.546	63.086	1.542
1972	1.671	1.685	67.403	1.686
1973	2.567	2.558[1]	103.783	2.544
1974	4.595	4.708	199.819	4.675
1975	4.503	4.419	200.118	4.446
1976	4.291	4.353	242.423	4.377
1977	4.922	4.623	265.512	4.634
1978	6.171	5.401	282.203	5.423
1979	12.974	11.094	519.607	11.026
1980	24.099	20.632	900.778	20.872

Sources: Canadian prices as quoted in the **Northern Miner** (arithmetical average of daily quotations). United States and United Kingdom prices as quoted in **Metals Week.**

[1] The 60-day general price freeze in effect in the United States from June 13 through August 12, 1973 forced intermittent suspension of Handy & Harman's daily quotation during July and August for a total of 22 days. [2] Prices are expressed in new British pence, following British conversion to decimal currency, February 11, 1971, at the rate of 100 pence per pound sterling. Previous rate was 240 pence per pound. [3] Prices have been converted at the yearly average exchange rates quoted by **Metals Week.**

The silver price was comparatively stable during the months of April and May though the general trend was downwards. In May the monthly average silver price was $12.53 per ounce, the lowest of any month in 1980. The low silver price of $10.80 occurred on May 22. The price began to move upwards in June and reached a monthly average of $20.17 in October before declining again in November, partly on the uncertainty following the election in the United States. The decline continued in December, just the opposite of the highly volatile rising market of a year earlier.

The average silver price for the year 1980, as quoted by Handy & Harman of New York, was $US 20.63 an ounce compared with $11.09 in 1979. The London spot silver price, which closely paralleled the United States price, averaged 900.78 pence ($US 20.87) per ounce.

In 1980, the Canadian silver price closely followed its United States counterpart, with the essential difference being the currency exchange differential. The average Canadian silver price (Handy & Harman) in 1980 was $774.23 per kg ($Cdn 24.10 per troy ounce) compared with $417.35 per kg ($12.97 per ounce in 1979).

OUTLOOK

Canada's primary production of silver is expected to be about 1 230 t in 1981 and about 1 350 t in 1982. In the medium term, output should stabilize near the 1982 level but Canada will continue to be one of the world's largest producers and exporters of silver.

World consumption of silver in 1980, including coinage, was 11 070 t as estimated by Handy & Harman of New York, a decrease of 20.5 per cent from the 13 922 t consumed in 1979. The sharp increase in the silver price was largely responsible for lower silver consumption. With the exception of Japan, which reported only a small decline in consumption, the industrialized countries reported substantially lower silver consumption. The major categories of silver usage reporting lower consumption were photography, sterling ware and electronic and electronic industries. Because of the superiority of silver in its many applications it is expected that consumption will recover in 1981 and be near that of 1979. Research to date has not developed a satisfactory substitute to replace silver in the photographic industry and consumption in this field is expected to be strong.

In the past, normal supply-demand forces predominated in determining the price of silver. Since 1979, speculators, hoarders and investors have played a major role in determining price movements. This group is expected to continue to have a strong if not the major influence in price determination.

The high price of silver, especially in the early part of 1980, brought a significant increase in silver production from secondary sources, including demonetized coins and the photographic industry. It is difficult to estimate the amount of silver recovered from scrap but Samuel Montagu & Co. Limited of the United Kingdom estimated silver recovery from this source at 4 750 t in 1980 compared with 2 675 t in 1979, an increase of over 77 per cent. Higher silver prices will continue to encourage silver recovery from secondary sources but future supplies are unlikely to reach levels generated in the early part of 1980 because holders of coins, silverware, heirlooms, etc. will retain many of these items for their collector value. India has been a significant source of secondary silver in the past but restrictions placed on exports will reduce the amount of silver available from this source although some will be available through smuggling.

Developments under way or planned throughout the world should increase annual world production of silver by between 780 and 1 090 t in the short term. About 80 per cent of the world's primary silver output is derived as a byproduct or coproduct of base-metal ores and any increase in silver output from this source will depend on the demand for base-metals rather than the price of silver. Increased silver output will therefore depend on mines brought into production in which silver is the major metal. For this to occur, the silver price must remain at a relatively high level and show some stability. Increased production from this source can be expected in Mexico, the western United States and other Central American countries. Because of the time period involved in exploring, financing and developing new properties, no sharp increase in output is expected in the medium term other than from those developments already under way.

Over the years there has been a substantial shortfall between world production of new silver and consumption in the non-communist world, which was balanced from above-ground stocks, especially from India. These stocks are large and the recent sharp rise in the silver price has brought increased amounts of recycled silver to the market. The combination of primary production, lower consumption because of the increased silver price and the increase in secondary silver created a situation of surplus silver stocks in 1980 which were absorbed by speculators. The demand-supply relationship in the short term will be complex. Silver prices are expected to be erratic in 1981 but the chaotic price movements that took place in the latter part of 1979 and early 1980 are not expected to occur in 1981.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
32900-1	Ores of metals, nop	free	free	free	free
35800-1	Anodes of silver	free	free	10	free
35900-1	Silver in ingots, blocks, bars, drops, sheets or plates, unmanufactured; silver sweepings	free	free	free	free
35905-1	Scrap silver and metal alloy scrap containing silver	free	free	25	free
36100-1	Silver leaf	12.5	18.9	30	12.5
36200-1	Articles consisting wholly or in part of sterling or other silverware, nop; manufactures of silver, nop	15.7	21.1	45	14

TARIFFS (cont'd)

MFN Reductions under GATT (effective January 1 of year given)

	1980	1981	1982	1983	1984	1985	1986	1987
				(%)				
36100-1	18.9	17.8	16.7	15.7	14.6	13.5	12.4	11.3
36200-1	21.1	19.6	18.2	16.8	15.3	13.9	12.4	11.0

UNITED STATES

Item No.		
601.39	Precious metal ores, silver content	Free
605.20	Silver bullion, silver dore and silver precipitates	Free
605.70	Precious metal sweepings and waste and scrap, silver content	Free
644.56	Silver leaf	2.5¢ per 100 leaves

		1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
420.60	Silver compounds	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
605.46	Platinum-plated silver, unwrought or semi-manufactured	14.9	13.9	12.8	11.8	10.7	9.6	8.6	7.5
605.47	Gold-plated silver, unwrought or semi-manufactured	23.1	21.3	19.4	17.5	15.6	13.8	11.9	10.0
605.48	Other unwrought or semi-manufactured silver	9.9	9.4	8.8	8.3	7.7	7.1	6.6	6.0
605.65	Rolled silver, unworked or semi-manufactured	9.9	9.4	8.8	8.3	7.7	7.1	6.6	6.0

EUROPEAN ECONOMIC COMMUNITY (MFN)

Item No.		1980	Base Rate	Concession Rate
			(%)	
28.49	Colloidal silver, amalgams, salts and other compounds of silver			
A.	Colloidal silver	7.7	8.0	5.3
B.	Amalgams of silver	7.7	8.0	5.3
C.	Salts and other compounds, inorganic or organic of silver	9.2	9.6	6.0
71.05	Silver, including silver gilt and platinum-plated silver, unwrought or semi-manufactured			
A.	Unwrought	Free	Free	Free
B.	Bars, rods, wire and sections, plates, sheets, strips	2.0	2.0	1.8
C.	Tubes, pipes and hollow bars	3.4	3.5	2.9

EUROPEAN ECONOMIC COMMUNITY (MFN) (cont'd)

Item No.		1980	Base Rate	Concession Rate
			(%)	
71.05 (cont'd)				
D.	Foil of a thickness, excluding any backing, not exceeding 0.15 mm	6.3	6.5	5.0
E.	Powder, purls, spangles, cuttings and other forms	4.9	5.0	3.8
71.06	Rolled silver, unworked, or semi-manufactured			
A.	Unworked	4.9	5.0	3.8
B.	Semi-manufactured	6.3	6.5	4.6
71.08	Rolled gold on silver, unworked or semi-manufactured	3.4	3.5	2.9
71.10	Rolled platinum or other platinum group metals on silver, unworked or semi-manufactured	3.4	3.5	2.9
71.11	Silversmiths sweepings, residues and other waste and scrap	Free	Free	Free
71.12	Articles of jewellery and parts thereof, of silver or rolled silver			
A.	Of silver	4.4	4.5	3.5
B.	Of rolled silver	8.6	9.0	5.8
71.13	Articles of silversmiths wares and parts thereof, of silver, other than above			
A.	Of silver	6.9	7.5	3.0
B.	Of rolled silver	4.9	5.0	3.8
71.14	Other articles of silver or rolled silver			
A.	Of silver	6.0	7.5	5.1
B.	Of rolled silver	5.8	6.0	4.4

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada, Tariff Schedules of the United States Annotated (1980), USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 22, No. L342, 1979; GATT Documents, 1979.
nop Not otherwise provided for.

Sodium Sulphate

G.S. BARRY

Sodium sulphate is an industrial chemical used principally in the manufacture of pulp and paper by the "kraft" process, and in the manufacture of detergents, glass and chemicals. It is produced from natural brines and deposits in alkaline lakes in areas with dry climates and restricted drainage, from subsurface deposits and brines, or as a byproduct of chemical processes. Canada's sodium sulphate industry is based on extraction from natural brines and deposits in several alkaline lakes in Saskatchewan and Alberta. Eight plants producing natural sodium sulphate operated in Canada in 1980. Byproduct sodium sulphate is recovered at one rayon plant and at three paper mills in Ontario.

In the United States, natural and byproduct sodium sulphate production is almost evenly split. Natural sodium sulphate is produced in California, Texas and Utah. In 1979, the Kerr-McGee Corporation, which produces sodium sulphate from brines at Searles Lake, California, completed a major expansion program increasing its production capability by 136 000 tonnes per year (tpy). After some start-up delays, the operations reached capacity utilization in 1980, but at a level below original expectations.

In Europe, sodium sulphate is produced almost entirely as a byproduct of chemical processes.

PRODUCTION AND DEVELOPMENTS IN CANADA

Markets remained strong for the second successive year. Shipments of natural sodium sulphate from Canadian producers increased by 11.9 per cent to 496 000 t in 1980 but were still much below the record level of 638 000 t achieved in 1974. The unit value of shipments increased from $56.87 in 1979 to $58.33 per t in 1980, reflecting steady demand from the pulp and paper and detergent industries.

Deposits. In addition to the lakes in Saskatchewan and Alberta, sodium sulphate has been found in association with magnesium sulphate in lakes in British Columbia and with calcium sulphate in deeply buried deposits of glauberite in New Brunswick. Only minor production has been obtained in British Columbia and none in New Brunswick.

The sodium sulphate deposits in Saskatchewan and Alberta have formed in shallow, undrained lakes and ponds where in-flow is greater than out-flow. Percolating ground waters carry dissolved salts into the basins from the surrounding soils. High rates of summer evaporation concentrate the brine to near saturation, and cooler fall temperatures cause crystallization and precipitation of sodium sulphate as mirabilite ($Na_2SO_4 \cdot 10H_2O$). The cycle has been

TABLE 1. CANADA, SODIUM SULPHATE PRODUCTION AND TRADE, 1979 AND 1980

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Production				
Shipments				
Saskatchewan	..	23,149,794	..	26,205,000
Alberta	..	2,061,337	..	2,725,000
Total	443 279	25,211,131	496 000	28,930,000
Imports				
Total salt cake and Glauber's salt				
United Kingdom	22 377	727,000	19 536	701,000
United States	779	175,000	675	123,000
Total	23 156	902,000	20 211	824,000
Exports				
Crude sodium sulphate				
United States	191 409	13,103,008	236 704	18,285,000
Thailand	-	-	2 989	492,000
Other countries	1 859	220,000	6 140	1,134,000
Total	193 268	13,323,000	245 833	19,911,000

Source: Energy, Mines and Resources Canada.
P Preliminary; .. Not available; - Nil.

TABLE 2. CANADA, NATURAL SODIUM SULPHATE PLANTS, 1980

	Plant Location	Source Lake	Annual Capacity (tonnes)
Alberta			
Alberta Sulphate Limited	Metiskow	Horseshoe	75 000
Saskatchewan			
Francana Minerals Ltd.	Grant	Snakehole	63 000
Francana Minerals Ltd.	Hardene	Alsask	42 500
Midwest Chemicals Limited	Palo	Whiteshore	109 000
Ormiston Mining and Smelting Co. Ltd.	Ormiston	Horseshoe	90 700
Saskatchewan Minerals	Chaplin	Chaplin	90 000
Saskatchewan Minerals	Bishopric[1]	Frederick	45 000
Saskatchewan Minerals	Fox Valley	Ingebrigt	135 000
Sybouts Sodium Sulphate Co., Ltd.	Gladmar	East Coteau	45 400
Total			695 600

Source: Company reports.

[1] Closed at end of June 1977 and re-opened in April 1980.

repeated year after year and thick deposits of hydrous sodium sulphate, accompanied by other salts and mud, have accumulated. Occasionally, where sodium chloride is present, some of the sodium sulphate is precipitated as thenardite (Na_2SO_4), the anhydrous variety of the salt.

Some lakes have not accumulated thick beds because the crystals of sodium sulphate deposited in the fall and winter are redissolved each spring, to re-form a brine rich in sodium sulphate. These same lakes commonly contain a high concentration of magnesium sulphate, a mineral that may prove valuable in the future.

TABLE 3. CANADA, SODIUM SULPHATE PRODUCTION, TRADE AND CONSUMPTION 1970, 1975, 1976-80

	Production[1]	Imports[2]	Exports	Consumption
	(tonnes)			
1970	445 017	26 449	108 761	291 439
1975	472 196	22 638	178 182	256 385
1976	460 193	29 266	146 396	265 608
1977	394 795	34 639	117 027	254 872
1978	376 563	25 178	129 029	236 766[r]
1979	443 279	23 156	193 268	255 059
1980[p]	496 000	20 211	245 833	..

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Producers' shipments of crude sodium sulphate. [2] Includes Glauber's salt and crude salt cake.
[p] Preliminary; [r] Revised; .. Not available.

Deposits in Saskatchewan have been identified that contain, in total, approximately 90 million t of anhydrous sodium sulphate. Of this amount, a total of about 51 million t is in 21 individual deposits, each containing more than 500 000 t of sodium sulphate. One deposit in Alberta contains 2.7 million t of Na_2SO_4. Exploitation currently takes place on the following lakes (with reserves, in millions of t, in brackets): Whitehorse Lake (6.5), Horseshoe Lake (3.7), Frederic Lake (2.4), Chaplin Lake (3.0), Ingebrigt Lake (9.0), Alsack Lake (2.6), East Coteau Lake (3.5) and Snakehole Lake (1.7), all in Saskatchewan. Production in Alberta is from Horseshoe Lake (3.0).

Recovery and processing. Because sodium sulphate is recovered by evaporation of concentrated brines or by dredging of the permanent beds of crystals, weather is as important for recovery of sodium sulphate as it is for its deposition. A large supply of fresh water is also essential. One method of sodium sulphate recovery is to pump lake brines that have been concentrated by hot summer weather into evaporating ponds or reservoirs. Continued evaporation produces a saturated or near-saturated solution of mirabilite. Differential crystallization occurs in the fall when the solution cools. Hydrous sodium sulphate crystallizes and precipitates, whereas sodium chloride, magnesium sulphate and other impurities remain in solution. Before freezing weather sets in, the impure solution remaining in the reservoir is drained or pumped back into the source lake. After the crystal bed has become frozen, harvesting is carried out using conventional earth-moving equipment. The harvested crystal is stockpiled adjacent to the plant.

In Saskatchewan, three operators: Francana Minerals Ltd. at Snakehole Lake, Ormiston Mining and Smelting Co. Ltd. at Horseshoe Lake, and Sybouts Sodium Sulphate Co., Ltd. at East Coteau Lake, use floating dredges to mine the permanent crystal bed. The slurry of crystal and brine is transported to a screening house at the plant by pipeline. If sufficiently concentrated, the brine from the screens is collected in an evaporation pond.

The Ingebrigt Lake plant of Saskatchewan Minerals uses a combination of dredging and solution mining, and pumps a concentrated brine to an air-cooled crystallizer at the plant, where sodium sulphate is separated from other insoluble salts. At the Chaplin Lake plant, after precipitation in the brine reservoir, the water is drained back into the lake, permitting mechanical harvesting of the precipitate. Removal of the crystallized sodium sulphate usually takes place in the coldest months of January and February. The processing method at Alberta Sulphate Limited's plant at Horseshoe Lake combines dredging and solution mining. Crystallizers are used mainly to separate mud from salt cake.

Processing of a natural salt consists of dehydration (Glauber's salt contains 55.9 per cent water of crystallization) and drying. Commercial processes used in Saskatchewan include Holland evaporators, gas-fired rotary kilns, submerged combustion and multiple effect evaporators. Auxiliary equipment includes screens, classifiers, centrifuges, rotary kiln driers and crushers. Salt cake, the product used principally in the pulp and paper industry, contains a minimum of 97 per cent Na_2SO_4. Detergent-grade material analyzes up to 99.7 per cent Na_2SO_4. Uniform grain size and free-flow characteristics are important in material handling and use.

TABLE 4. CANADA, AVAILABLE DATA ON SODIUM SULPHATE CONSUMPTION, 1978-80

	1978	1979	1980
	(tonnes)		
Pulp and paper	176 074	203 097	..
Soaps	33 786	41 218	..
Glass and glass wool	17 410	9 859	..
Other products[1]	9 496	885	..
Total	236 766	255 059	..

Source: Statistics Canada, breakdown by Energy, Mines and Resources Canada.

[1] Colours, pigments, feed supplements and other minor uses.
.. Not available.

Of the eight plants in the prairies, three are capable of producing detergent-grade sodium sulphate. Each of the three plants has the capacity to produce 80 per cent or more of its output as a high-grade product.

Byproduct recovery. Courtaulds (Canada) Inc. produces approximately 20 000 t of detergent-grade sodium sulphate as a byproduct of viscose rayon production at its Cornwall, Ontario plant. Ontario Paper Company Limited at Thorold, Ontario produced 69 000 t of salt cake in 1980, (68 000 t in 1979) as a byproduct of paper manufacturing. It is mostly used in the glass industry and 60 per cent is exported. The capacity of the Thorold plant is 77 000 tpy. The Great Lakes Paper Company, Limited at Thunder Bay, produces salt cake for internal consumption (about 15 000 tpy in 1980) and expanded capacity to about 25 000 tpy in 1980.

The three principal consumers of sodium sulphate are: the kraft pulp and paper industry, the detergent industry and the glass industry. Other users include the dyeing industry and the producers of mineral feed supplements and chemical products. Because of reduced activity in the pulp and paper industry in North America, and reduction of usage per unit of output, consumption of salt cake was on the decline between 1974 and 1978. The detergent market, however, remained strong. In 1979 and 1980 North American markets had a good recovery.

TABLE 5. CANADA, RAILWAY TRAIN LOADINGS OF SODIUM SULPHATE, 1979 AND 1980

	1979	1980P
	(tonnes)	
Nova Scotia	-	..
New Brunswick	562	..
Quebec	829	..
Ontario	47 427	..
Manitoba	-	..
Saskatchewan	390 586	..
Alberta	31 472	..
British Columbia	63 580	..
Canada	534 456	..

Source: Statistics Canada.
P Preliminary; - Nil; .. Not available.

Canadian exports of sodium sulphate in 1980 were 236 704 t, an increase of 27.2 per cent from the 191 409 t exported in 1979. This was a remarkable achievement, considering that exports already increased by 50 per cent between 1978 and 1979. Production delays at the California plant in 1979 and early 1980 greatly improved this export picture. About 60 per cent of exports to the United States are detergent-grade. Imports in 1980 decreased by 12.7 per cent to 20 211 t, compared with 1979. Almost all imports were from the United Kingdom, as the United States ceased to be a significant supplier.

OUTLOOK

Outlook for Canadian sales in 1981 remains excellent, with growth continuing in the export market to reach the 250 000 t to 300 000 t level and then stabilizing for one to two years. The longer term growth in sodium sulphate demand in North America will come mainly from the detergent industry sector (2% to 3% per year) and possibly the power industry, where sodium sulphate is increasingly used as a conditioner in coal-burning thermal plants to facilitate fly ash supression. In the United States this new market has the potential to expand substantially perhaps up to 300 000 tpy in the late 1980s.

The utilization of sodium sulphate for potassium sulphate production in Saskatchewan is another factor that would spur production in western Canada; however, technical and economic evaluations are continuing and it is too early to forecast this new usage with any degree of certainty at present. It is surmised however, that tonnages of sodium sulphate required by a potassium sulphate plant would be within the range of 100 000 to 300 000 tpy.

U.S. commodity experts, however, still forecast overall marginal decreases or no growth in sodium sulphate consumption in the decade of the 1980s since consumption in other traditional sectors, for example sodium sulphate usages in the pulp and paper industry, is declining.

PRICES

Canadian prices of sodium sulphate, as quoted in "Canadian Chemical Processing Newsletter", December 1, 1980.

	($Cdn. per t)
Sodium sulphate (salt cake)	
Regular, bulk, carlots, fob works	55.00
Detergent grade bulk, carlots, fob works	74.00

United States prices as quoted in "Chemical Marketing Reporter", November 24, 1980.

	($US per short ton)
Salt cake, domestic, bulk, 100% Na_2SO_4 basis, fob plant, East	47.00-52.00
Same basis, West	45.00
Sodium sulphate, technical, detergent, rayon-grade, bags, carlots, works, East	70.00-72.00

fob Free on Board.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
21000-1	Natural sodium sulphate	10.0	14.7	25.0	9.5

MFN reductions under GATT (effective January 1 of year given)

	1980	1981	1982	1983	1984	1985	1986	1987
21000-1	14.7	14.4	14.1	13.8	13.4	13.1	12.8	12.5

UNITED STATES: Custom Tariffs (MFN)

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
421.42	Crude sodium sulphate	Remains free							
421.44	Anhydrous (per long ton)	39¢	38¢	37¢	36¢	36¢	35¢	34¢	33¢
421.46	Crystallized	3%	3%	2.9%	2.8%	2.7%	2.7%	2.6%	2.5%

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada. Tariff Schedules of the United States Annotated 1980, USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241.

Stone

D.H. STONEHOUSE

CANADIAN INDUSTRY

Production of stone of all types in Canada in 1980 decreased about 6 per cent to 103 million tonnes (t), while the unit value of production increased by over 9 per cent. Stone is produced in direct response to the demands of the construction industry, which utilizes 95 per cent of output principally as crushed stone. Less than one per cent of stone production is used as building stone in the form of panels or blocks now that concrete products have become widely accepted in such applications. There are, however, periodic surges of interest in Canadian stone for building uses, particularly Canadian black granites. The chemical uses are limited to the cement, lime, glass and metal-smelting industries and account for about 3 per cent of stone production, mainly limestone. The remaining 2 per cent is consumed in pulverized form as filler and extender materials.

The large number of stone-producing operations in Canada precludes describing within this review individual plants or facilities. Many are part-time or seasonal operations, many are operated subsidiary to construction or manufacturing activities by establishments not classified to the stone industry, and some are operated directly by municipal or provincial government departments producing stone for their own direct use. Detailed information can be obtained through the individual provincial departments of mines or equivalent. Most provinces have accumulated data relative to occurrences of stone of all types and in many cases have published such studies. The federal government, through the Geological Survey of Canada, has also gathered and published a great number of geological papers pertaining to stone occurrences. Works by W.A. Parks[1] and by M.F. Goudge[2] have become classics in the fields of building stones and limestones, respectively.

Atlantic provinces. Limestone. The many occurrences of limestone in the Atlantic provinces have been systematically catalogued during the past few years[3,4,5]. Deposits of commercial importance are being worked in three of the four provinces.

In Newfoundland limestone is available from small, impure exposures in the eastern portion of the island, from small, high-calcium deposits in the central region, and from large, high-purity, high-calcium occurrences in the west. Other than periodic operation to secure aggregate for highway work, the main exploitation is by North Star Cement Limited at Corner Brook[6]. Large quantities of high-calcium limestone have been outlined in the Port au Port district. The provincial government continued through 1980 a program to identify available aggregates near major use centres and adjacent to the Trans Canada Highway route through the province.

In Nova Scotia limestones occur in the central and eastern parts of the province in thin, tilted lenses typical of deposits in

TABLE 1. CANADA, TOTAL PRODUCTION (SHIPMENTS) OF STONE, 1978-80

	1978		1979		1980P	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
By province						
Quebec	76 218 682	198,504,209	63 251 049	185,072,776	55 336 000	178,773,000
Ontario	33 815 562	94,517,217	33 439 385	102,095,244	34 019 000	112,500,000
British Columbia	3 433 566	11,996,038	4 353 417	14,929,542	4 536 000	16,250,000
New Brunswick	3 121 279	9,897,442	3 122 185	9,913,820	3 266 000	10,800,000
Nova Scotia	1 980 332	6,245,093	2 181 372	7,682,578	2 359 000	8,450,000
Manitoba	2 678 311	8,628,186	1 923 781	7,100,466	2 177 000	8,040,000
Newfoundland	654 895	2,163,560	1 262 033	2,922,962	1 361 000	3,375,000
Alberta	241 181	792,524	185 958	990,314	227 000	1,250,000
Canada	122 143 808	332,744,269	109 719 180	330,707,702	103 281 000	339,438,000
By use						
Building stone						
Rough	524 115	3,185,951	256 483	3,093,971	..	..
Monumental and ornamental stone	24 663	1,779,410	30 164	2,410,524	..	..
Other (flagstone, curbstone, paving blocks, etc.)	31 901	1,252,980	34 635	1,702,503	..	..
Chemical and metallurgical						
Cement plants, foreign	1 219 039	1,994,429	1 256 432	2,136,095	..	..
Lining, open-hearth furnaces	31 370	71,683	31 395	85,284	..	..
Flux in iron and steel furnaces	413 868	1,670,474	1 132 659	3,800,996	..	..
Flux in nonferrous smelters	42 752	189,272	265 626	1,919,918	..	..
Glass factories	257 949	2,360,198	229 922	2,097,788	..	..
Lime kilns, foreign	342 283	925,854	168 318	435,297	..	..
Pulp and paper mills	310 305	2,212,908	291 165	2,072,256	..	..
Sugar refineries	27 864	160,240	82 941	412,382	..	..
Other chemical uses	1 072 155	4,333,833	340 671	2,669,713	..	..
Pulverized stone						
Whiting (substitute)	27 167	1,043,623	28 282	1,197,352	..	..
Asphalt filler	25 371	245,989	33 695	290,931	..	..
Dusting, coal mines	3 674	60,300	6 409	100,441	..	..
Agricultural purposes and fertilizer plants	966 298	7,037,548	994 055	7,401,523	..	..
Other uses	60 494	357,441	532 688	2,242,687	..	..

Crushed stone for						
Manufacture of artificial stone	17 669	220,212	20 501	259,742	..	..
Roofing granules	274 119	9,640,539	342 429	13,967,379	..	..
Poultry grit	50 395	628,824	96 453	878,400	..	..
Stucco dash	22 561	1,026,687	26 593	1,206,168	..	..
Terrazzo chips	4 361	141,134	7 906	211,523	..	..
Rock wool	-	-	16 784	12,639	..	..
Rubble and riprap	40 430 659	79,388,652	26 077 326	54,630,244	..	..
Concrete aggregate	12 373 703	35,384,224	10 900 691	31,678,978	..	..
Asphalt aggregate	6 622 217	18,852,198	6 732 002	20,325,686	..	..
Road metal	24 536 390	69,034,613	24 869 549	72,753,220	..	..
Railroad ballast	3 396 582	12,589,742	3 290 496	11,261,645	..	..
Other uses	29 033 884	76,955,311	31 622 910	89,452,417	..	..
Total	122 143 808	332,744,269	109 719 180	330,707,702	..	..

Source: Energy, Mines and Resources Canada
P Preliminary; - Nil; .. Not available.

Atlantic Canada and in contrast to deposits of much greater thickness and areal extent in central Canada. Large proven reserves in the Glencoe region of Inverness County have been assessed with the object of establishing a portland cement facility on site or at the Strait of Canso to supply an offshore market. A buoyant and continuing market for cement and clinker would be necessary to support such an undertaking.

In New Brunswick limestone is quarried at three locations - Brookville, Elm Tree and Havelock - for use as a crushed stone, as an aggregate, for agricultural application, for cement and lime manufacture, and for use as a flux.

Granite. Occurrences of granites in the Atlantic region have been described by Carr[7]. Current operations in Nova Scotia are at Nictaux, Shelburne and Erinville. A grey granite is produced from operations near Nictaux and from one quarry at Shelburne for use mainly in the monument industry. A black granite from Shelburne and a diorite from Erinville are used for monuments and for dimension stone. Quartzitic rock referred to as "bluestone" is quarried at Lake Echo, north of Dartmouth, for use as facing stone. Crushed quartzite for use as an aggregate is produced at a number of locations in Halifax County. At Folly Lake in Colchester County a diorite is quarried, mainly for use as railway ballast. A new quarry in a "quartzite-granite" on the mainland side of the Strait of Canso has been opened recently to supply aggregate material to Prince Edward Island and other Atlantic areas. The company indicates its long-term objectives include marketing aggregates in offshore regions.

Granites are quarried intermittently from a number of deposits within New Brunswick to obtain stone of required colour and texture for specific application. A red, fine- to medium-grained granite is quarried near St. Stephen, and fine-grained, pink, grey and blue-grey granites are available in the Hampstead (Spoon Island) district. In the Bathurst area, a brown-to-grey, coarse-grained granite is quarried upon demand, as is a salmon-coloured, medium-grained granite near Antinouri Lake, and a black, ferromagnesian rock in the Bocabec River area. Red granite is available in the St. George district. Granite for use as a crushed stone is produced near Fredericton and near Moncton.

Sandstone. A medium-grained buff sandstone is quarried at Wallace, Nova Scotia, for use as heavy riprap and for dimension stone applications. Small deposits in many parts of the province are quarried periodically for local use.

In New Brunswick, a red, fine-to medium-grained sandstone has been quarried in Sackville for use in construction of buildings on the Mount Allison University campus. Deposits are exploited from time to time throughout Kent and Westmorland counties for local projects and for highway work.

Quebec. Limestone. Limestone occurs in the St. Lawrence and Ottawa River valleys and in the Eastern Townships. Other major deposits in the province are located in the Gaspé region. The limestones range in age from Precambrian to Carboniferous and vary widely in purity, colour, texture and chemical composition[2]. Quarries are located near major market areas such as Montreal, Quebec City, Sherbrooke, Ottawa-Hull and Trois-Rivières and supply crushed stone to the construction industry, mainly for use in concrete and asphalt and as highway subgrade.

Limestone blocks and other shapes are produced for the construction trade in the Montreal region and at various locations throughout the province as the need arises. Marble has been produced in the Stukely and Philipsburg areas.

Granite. Normally about 60 per cent of Canada's granite production comes from Quebec from long-established operations in two general regions - one north of the St. Lawrence and Ottawa Rivers, including the Lac Saint-Jean area, and one south of the St. Lawrence River. Precambrian rocks contain granites of various colours, compositions and textures. Although many areas underlain by granite are too remote from transportation and markets to be economically viable, the provincial government is gathering detailed data on some attractive deposits with the view to future exploitation.

Sandstone. There are far fewer sandstone-producing operations in Quebec than there are producers of limestones and granites. Of six operations producing from sandstone resources only one is listed as marketing flagstone and construction blocks[8].

TABLE 2. CANADA, PRODUCTION (SHIPMENTS) OF LIMESTONE, 1978 and 1979

	1978		1979	
	(000 t)	($000)	(000 t)	($000)
By province				
Newfoundland	537	1,619	1 131	2,343
Nova Scotia	203	1,711	245	2,119
New Brunswick	679	3,651	560	3,381
Quebec	24 320	72,092	24 520	74,928
Ontario	31 620	78,555	31 337	82,318
Manitoba	1 462	3,818	1 362	3,525
Alberta	74	523	186	979
British Columbia	2 644	8,977	2 611	9,338
Canada	61 539	170,946	61 952	178,931
	(tonnes)	($)	(tonnes)	($)
By use				
Building stone				
Rough	475 140	1,262,518	219 605	1,308,897
Monumental and ornamental	816	33,000	453	50,000
Other (flagstone, curbstone, paving blocks, etc.)	10 341	365,602	7 549	245,246
Chemical and metallurgical				
Cement plants, foreign	1 219 039	1,994,429	1 256 432	2,136,095
Lining, open-hearth furnaces	31 370	71,683	31 395	85,284
Flux, iron and steel furnaces	413 868	1,670,474	1 132 659	3,800,996
Flux, nonferrous smelters	42 620	187,556	265 460	1,917,540
Glass factories	257 949	2,360,198	229 922	2,097,788
Lime kilns, foreign	342 284	925,854	168 318	435,297
Pulp and paper mills	301 901	2,128,969	282 426	1,974,265
Sugar refineries	27 864	160,240	82 941	412,382
Other chemical uses	945 756	4,210,580	340 670	2,669,713
Pulverized stone				
Whiting substitute	27 167	1,043,623	28 282	1,197,352
Asphalt filler	25 371	245,989	33 696	290,931
Dusting, coal mines	3 674	60,300	6 409	100,441
Agricultural purposes and fertilizer plants	883 069	6,458,033	925 914	6,886,141
Other uses	50 507	268,190	530 419	2,185,232
Crushed stone for				
Artificial stone	934	29,625	327	9,360
Roofing granules	57 060	279,321	74 092	628,068
Poultry grit	44 316	554,311	95 872	861,754
Stucco dash	22 561	1,026,687	22 618	1,135,215
Rubble and riprap	2 090 668	5,658,137	1 040 503	2,320,850
Concrete aggregate	10 575 756	28,581,483	9 604 904	26,821,164
Asphalt aggregate	5 230 634	14,459,441	4 793 825	13,405,182
Road metal	19 255 874	52,530,204	19 899 554	55,241,035
Railroad ballast	1 059 234	2,824,352	1 376 192	3,220,899
Other uses	18 143 602	41,555,230	19 502 116	47,493,959
Total	61 539 375	170,946,029	61 952 553	178,931,086

Source: Energy, Mines and Resources Canada.

TABLE 3. CANADA, PRODUCTION (SHIPMENTS) OF MARBLE, 1978 and 1979

	1978		1979	
	(000 t)	($000)	(000 t)	($000)
By province				
Quebec	380	1,972	382	2,042
Ontario	2	91	3	134
Canada	382	2,063	385	2,176
	(tonnes)	($)	(tonnes)	($)
By use				
Chemical process stone				
Flux in nonferrous smelters	133	1,716	166	2,378
Pulp and paper mills	8 404	83,939	8 739	97,991
Pulverized stone				
Agricultural purposes and fertilizer plants	83 229	579,515	68 141	515,382
Other uses	9 987	89,251	2 269	57,455
Crushed stone				
For manufacture of artificial stone	16 735	190,587	20 175	250,382
Stucco dash	-	-	3 975	70,953
Terrazzo chips	4 361	141,134	7 907	211,523
Concrete aggregate	50 663	316,803	48 997	320,905
Asphalt aggregate	13 363	76,596	-	-
Road metal	78 571	256,499	111 225	327,444
Roofing granules	1 412	21,800	2 038	37,716
Poultry grit	5 543	60,957	-	-
Rubble and riprap	9 427	19,385	-	-
Other uses	100 701	225,119	111 748	284,454
Total	382 529	2,063,301	385 380	2,176,583

Source: Energy, Mines and Resources Canada.
- Nil.

TABLE 4. CANADA, PRODUCTION (SHIPMENTS) OF GRANITE, 1978 and 1979

	1978		1979	
	(000 t)	($000)	(000 t)	($000)
By province				
Newfoundland	9	94	14	117
Nova Scotia	1	14	1	17
New Brunswick	2 037	5,225	2 401	6,414
Quebec	49 331	117,236	36 463	100,819
Ontario	2 055	15,427	1 921	19,270
Manitoba	1 216	4,810	562	3,576
British Columbia	790	3,019	1 742	5,591
Canada	55 439	145,825	43 104	135,804

TABLE 4. (Cont'd.)

	(tonnes)	($)	(tonnes)	($)
By use				
Building stone				
Rough	26 935	1,165,570	16 243	1,060,772
Monumental and ornamental	23 804	1,743,381	29 442	2,356,084
Other (flagstone, curbstone, paving blocks, etc.)	13 277	619,869	18 174	1,150,841
Pulverized stone				
Asphalt filler	-	-	-	-
Crushed stone for				
Roofing granules	215 646	9,339,418	266 299	13,301,595
Poultry grit	536	13,556	580	16,646
Rubble and riprap	37 961 828	72,899,983	24 946 183	52,139,603
Concrete aggregate	1 381 531	5,044,447	883 822	2,971,116
Asphalt aggregate	1 116 987	3,447,052	1 577 146	5,258,422
Road metal	4 013 543	12,706,117	3 893 056	14,003,459
Railroad ballast	1 978 317	8,274,637	1 601 613	6,331,070
Other uses	8 707 045	30,571,100	9 871 804	37,213,918
Total	55 439 449	145,825,130	43 104 362	135,803,526

Source: Energy, Mines and Resources Canada.
- Nil.

Ontario. Limestone. Although limestones in Ontario range from Precambrian through Devonian, the major production comes from Ordovician, Silurian and Devonian deposits[9,10]. Of particular importance are the limestones and dolomite from the following geological sequences: the Black River and Trenton formations, extending from the lower end of Georgian Bay across southern Ontario to Kingston; the Guelph-Lockport Formation, extending from Niagara Falls to the Bruce Peninsula and forming the Niagara Escarpment; and the Middle Devonian limestone extending from Fort Erie through London and Woodstock to Lake Huron. Production of building stone, fluxstone and crushed aggregate from the limestones of these areas normally accounts for about 90 per cent of total stone production in Ontario.

Marble is widely distributed over southeastern Ontario and, according to the Ontario Ministry of Natural Resources reports, underlies as much as 250 square kilometres (km^2)[11].

The filler markets have become extremely attractive recently, not only to new ventures but also to companies hitherto interested in production of only coarser aggregate materials. Many lime operations now produce a filler-grade limestone product.

Granite. Granites occur in northern, northwestern and southeastern Ontario[12]. Few deposits have been exploited for the production of building stone because the major-consuming centres are in southern and southwestern Ontario where ample, good-quality limestones and sandstones are readily available. The areas most active in granite building stone production have been the Vermilion Bay area near Kenora, the River Valley area near North Bay, and the Lyndhurst-Gananoque area in southeastern Ontario. Rough building blocks were quarried from a gneissic rock near Parry Sound, while at Havelock a massive red-granite rock was quarried.

Sandstone. Sandstone quarried near Toronto, Ottawa and Kingston has been used widely in Ontario as building stone[13]. Production is currently from the Limehouse-Georgetown-Inglewood district where Potsdam sandstone is quarried. Medina sandstones vary from grey, through buff and brown to red, and some are mottled. They are fine- to medium-grained. The Potsdam stone is medium-grained; the colour ranges from grey-white through salmon-red to purple, and it can also be mottled. Current uses are as rough building stone, mill blocks from which sawn pieces are obtained, ashlar, flagstone and as a source of silica for ferrosilicon and glass.

Recent news releases from the Ontario Ministry of Natural Resources identified six major sites in eastern Ontario in which high-grade silica deposits occur. The Ministry study was undertaken to stimulate exploration that could develop silica resources to serve the Canadian consuming industries, which now use about 1.5 million t of silica per year.

Western provinces. Limestone. From east to west through the southern half of Manitoba rocks of the following ages are represented: Precambrian, Ordovician, Silurian, Devonian and Cretaceous. Limestones of commercial importance occur in the three middle periods and range from magnesian limestone through dolomite to high-calcium limestones[2,14].

Although building stone does not account for a large percentage of total limestone produced, the best known Manitoba limestone is Tyndall Stone, a mottled dolomitic limestone often referred to as "tapestry" stone. It is widely accepted as an attractive building stone, and is quarried at Garson, Manitoba, about 50 km northeast of Winnipeg.

Limestone from Moosehorn, 160 km northwest of Winnipeg and from Mafeking, 40 km east of the Saskatchewan border and 160 km south of The Pas, is transported to Manitoba and Saskatchewan centres for use in the metallurgical, chemical, agricultural and construction industries. Limestone from Steep Rock and from Lily Bay is used by cement manufacturers in Winnipeg, and limestone from Faulkner is now being used by the lime plant at Spearhill. The possibility of utilizing marl, an unconsolidated calcareous material, from deposits in the Sturgeon Lake region of Saskatchewan in the pulp and paper, cement, and lime industries has been investigated. Marl from a deposit 100 km north of Edmonton has been used as raw material in cement manufacture.

TABLE 5. CANADA, PRODUCTION (SHIPMENTS) OF SANDSTONE, 1978 and 1979

	1978		1979	
	(000 t)	($000)	(000 t)	($000)
By province				
Newfoundland	100	440	116	463
Nova Scotia	1 777	4,520	1 936	5,547
New Brunswick	404	1,022	160	118
Quebec	1 894	6,688	1 473	6,470
Ontario	12	321	6	254
Alberta	10	29	1	11
Canada	4 197	13,020	3 692	12,863
	(tonnes)	($)	(tonnes)	($)
By use				
Building stone				
Rough	22 040	757,863	20 635	724,302
Monumental and ornamental	42	3,029	268	4,440
Other (flagstone, curbstone, paving blocks, etc.)	8 283	267,509	8 912	306,416
Crushed stone for				
Rubble and riprap	368 736	811,147	8 253	9,702
Concrete aggregate	365 754	1,441,491	362 968	1,565,793
Asphalt aggregate	261 234	869,109	361 031	1,662,082
Road metal	1 089 102	3,349,118	920 325	3,086,306
Railroad ballast	359 031	1,490,753	312 691	1,709,676
Other uses	1 722 765	4,029,732	1 696 528	3,794,670
Total	4 196 987	13,019,751	3 691 611	12,863,387

Source: Energy, Mines and Resources Canada.

The eastern ranges of the Rocky Mountains contain limestone spanning the geologic ages from Cambrian to Triassic, with major deposits in the Devonian and Carboniferous periods in which a wide variety of types occur[15]. In southwestern Alberta, high-calcium limestone is mined at Exshaw, Kananaskis and Crowsnest, chiefly for the production of cement and lime, for metallurgical and chemical uses and for use as a crushed stone. Similar uses are made of limestone quarried at Cadomin, near Jasper[6].

In British Columbia large volumes of limestone are mined each year for cement and lime manufacture, for use by the pulp and paper industry and for various construction applications[6]. A large amount is exported to the northwestern United States for cement and lime manufacture. Four companies mined limestone on Texada Island, with the entire output being moved by barge to Vancouver and the State of Washington. Deposits on Aristazabal Island have been developed for the export market. Other operations at Terrace, Clinton, Westwold, Popkum, Dahl Lake, Doeye River and Cobble Hill produced stone for construction and for filler use[16]. Periodically, interest is revived in the possible use of travertine from a British Columbia source.

Granite. In Manitoba, at Lac du Bonnet northeast of Winnipeg, a durable, red granite is quarried for building and monument use. Grey granite located east of Winnipeg near the Ontario border is a potential source of building stone.

In British Columbia a light-grey, to blue-grey even-grained granodiorite of medium texture is available from Nelson Island. An andesite has been quarried at Haddington Island, off the northeast coast of Vancouver Island, for use as a building stone.

Sandstone. Sandstone for building and ornamental uses, quarried near Banff, Alberta is hard, fine-grained, medium-grey and is referred to as "Rundal Stone".

MARKETS

Naturally-occurring rock material, quarried or mined for industrial use with no change in its chemical state and with its physical character altered only by shaping or by sizing, is commercially termed "stone". Dimension stone is shaped for use as a building block, slab or panel. It may be rough-cut, sawn or polished, and its

TABLE 6. CANADA, PRODUCTION (SHIPMENTS) OF SHALE, 1978 and 1979

	1978		1979	
	(000 t)	($000)	(000 t)	($000)
By province				
Newfoundland	9	11	-	-
Quebec	292	515	412	813
Ontario	126	123	173	120
Alberta	158	241	-	-
Canada	585	890	585	933
	(tonnes)	($)	(tonnes)	($)
By use				
Chemical process stone				
Other uses	126 399	123,253	-	-
Crushed stone for				
Rubble and riprap	-	-	82 385	160,089
Road metal	99 299	192,675	45 389	94,976
Other uses	359 770	574,130	457 500	678,055
Total	585 468	890,058	585 274	933,120

Source: Energy, Mines and Resources Canada.
- Nil.

TABLE 7. CANADA, PRODUCTION (SHIPMENTS) OF STONE BY TYPES, 1970, 1976-79

	1970		1976		1977		1978		1979	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Granite	4 388 270	15,231,891	24 690 983	68,557,352	54 822 537	118,579,625	55 439 449	145,825,130	43 104 362	135 803 526
Limestone	52 522 637	67,563,790	57 793 006	146,699,824	60 161 235	160,392,862	61 539 375	170,966,029	61 932 553	178,931,086
Marble	56 096	350,903	398 317	1,974,468	396 906	2,062,221	382 529	2,063,301	385 380	2,176,583
Sandstone	2 112 794	4,133,708	3 693 917	11,298,041	3 834 010	13,336,685	4 196 987	13,019,751	3 691 611	12,863,387
Shale	180 087	695,458	1 299 715	2,108,777	967 914	2,195,937	585 468	890,058	585 274	933,120
Total	59 259 884	87,975,750	87 875 936	230,638,442	120 162 602	296,567,310	122 143 808	332,744,269	109 719 180	330,707,702

Sources: Energy, Mines and Resources Canada; Statistics Canada.

application may depend on its strength, hardness, durability and ornamental qualities. Broken, irregular, screened and sized pieces constitute the crushed stone category. Material in this category is used mainly as an aggregate in concrete and asphalt, in highway and railway construction and as heavy riprap for facing wharves and breakwaters.

Dimension stone. Granite, limestone, marble and sandstone are the principle rock types from which building and ornamental stone is fashioned. Over 90 per cent is used in construction-oriented projects, while less than 10 per cent is used as monument stone. Imports of rough blocks, particularly of granite, for sawing and polishing, as well as of finished stones for distribution to retailers, have cut into markets formerly supplied from domestic sources.

Today, in the building sector of the construction industry, granite, limestone and marble are used as facing stone in the form of cut and polished panels, in conjunction with steel and concrete, for institutional and commercial buildings. In residential buildings the use of limestone or sandstone ashlar, or coursing stone, is becoming increasingly popular. The emphasis has changed from stone used for structural purposes to stone used for its aesthetic qualities. The architect and contractor can design and build for lasting beauty using Canadian building stone.

High costs associated with quarrying, finishing, transporting and placing dimension stone in the building construction sector have contributed to the erosion of this industry and have made market penetration by concrete products possible.

Crushed stone. Many quarries that produce crushed stone are operated primarily to produce stone for other purposes, e.g., granite for building blocks and monuments, limestones for cement or lime manufacture, or for metallurgical use, marble for monuments and building panels, sandstone for riprap and cut stone. Quarries removing solid rock by drilling, blasting and crushing are not likely to be operated for small, local needs as are gravel pits and are, therefore, usually operated by large companies associated with the construction industry. Depending on costs and availability, crushed stone competes with gravel and crushed gravel as an aggregate in concrete and asphalt, and as railway ballast and road metal. In these applications it is subject to the same physical and chemical testing procedures as the gravel and sand aggregates.

Limestones are widely distributed in Canada and generally are available in sufficient quantity and with such chemical or physical specifications that long transportation hauls are unnecessary. Limestone products are low-priced commodities and only rarely, when a market exists for a high-quality, specialized product such as white portland cement or a high-purity extender, are they beneficiated or moved long distances. Provided the specifications are met, the nearest source is usually considered, regardless of provincial or national boundaries.

Over 70 per cent of Canada's annual production of limestone is used as crushed stone. This includes about 50 per cent used as road metal (broken, screened stone for asphalt roads), about 20 per cent as concrete aggregate and about 2 per cent as railroad ballast.

Some major uses in the chemical field are: neutralization of acid waste liquors; extraction of aluminium oxide from bauxite; manufacture of soda ash, calcium carbide, calcium nitrate and carbon dioxide; in pharmaceuticals; as a disinfectant; in the manufacture of dyes, rayons, paper, sugar and glass; and in the treatment of water. Dolomitic limestone is used in the production of magnesium chloride and other magnesium compounds.

Limestone is used in the metallurgical industries as a fluxing material where it combines with impurities in ore to form a fluid slag that can be separated from molten metal. Calcium limestones are used in open-hearth steel manufacture, whereas both calcium limestones and dolomitic limestones are used as a flux in the production of pig iron in blast furnaces.

Limestone is used extensively as a filler or an extender and, where quality permits, as whiting. In such applications both physical and chemical properties are important. Specifications vary widely but, in general, a uniform, white material passing 325 mesh would meet the physical requirements. Whiting is used in ceramic bodies, plastics, floor coverings, insecticides, paper, wood putty, rubber, paints and as a filler in many other commodities. In paint manufacture the material may be used as a pigment extender.

TABLE 8. CANADA, STONE EXPORTS AND IMPORTS, 1978-80

	1978		1979		1980P	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Exports						
Building stone, rough	17 471	975,000	6 377	769,000	5 019	723,000
Crushed limestone, limestone refuse	1 710 349	4,011,000	2 296 295	5,639,000	2 214 478	6,176,000
Stone crude, nes	294 049	656,000	296 121	1,817,000	67 051	1,250,000
Natural stone, basic products	..	3,730,000	..	6,909,000	..	7,928,000
Total		9,372,000		15,134,000		16,077,000
Imports						
Building stone, rough	11 022	893,000	10 803	1,032,000	9 330	985,000
Crushed limestone, limestone refuse	2 873 601	9,961,000	3 215 717	12,227,000	2 418 128	12,138,000
Crushed stone including stone refuse, nes	59 648	3,201,000	79 329	3,640,000	38 400	1,466,000
Stone crude, nes	605	699,000	625	545,000	20 164	1,054,000
Granite, rough	17 063	1,544,000	22 662	2,306,000	21 890	1,946,000
Marble, rough	5 937	1,307,000	8 694	1,622,000	6 656	2,290,000
Shaped or dressed granite	..	1,080,000	..	1,549,000	..	2,509,000
Shaped or dressed marble	..	1,442,000	..	1,602,000	..	1,858,000
Natural stone basic products	..	1,078,000	..	1,788,000	..	2,980,000
Total		21,205,000		26,311,000		27,226,000

Source: Statistics Canada.
P Preliminary; nes Not elsewhere specified; .. Not available.

Agricultural limestone is used to control soil acidity and to add calcium and magnesium to the soil. Limestone and lime are used as soil stabilizers, particularly on highway construction projects.

Dolomite is the source of magnesium metal produced at Haley, Ontario; the company also uses a high-calcium lime from southeastern Ontario in the production of calcium metal. Dead-burned dolomitic limestone for use as a refractory is produced at Dundas, Ontario, by Steetley Industries Limited.

Limestone from deposits in coastal areas of British Columbia is mined, crushed, loaded on barges of up to 20 000 t capacity, and transported as much as 600 km to consuming centres along the west coast in both Canada and the United States.

Comparatively small amounts of granite and sandstone are used as building and monument stone. Engineering construction projects, utilising all sizes from riprap to sand, are the principal consumer. High-silica sands can be the source of silica for glass and ceramics manufacture and for moulding sands. Canada currently imports nearly 80 per cent of its silica for these uses.

OUTLOOK

Crushed stone will continue to compete with sand and gravel for major markets where the latter are scarce. Through vertical integration, large operations based on construction materials can, by mergers and acquisitions, obtain captive markets for their products in operating construction firms.

TABLE 9. CANADA, VALUE OF CONSTRUCTION[1] BY PROVINCE, 1979-81

	1979			1980			1981		
	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total
Newfoundland	416 092	446 765	862 857	447 694	386 786	834 480	556 139	534 904	1 091 043
Nova Scotia	627 216	452 579	1 079 795	622 763	579 219	1 201 982	761 059	821 399	1 582 458
New Brunswick	594 170	476 357	1 070 527	531 303	433 661	964 964	575 808	469 438	1 045 246
Prince Edward Island	123 280	59 977	183 257	99 614	64 226	163 840	98 496	63 289	161 785
Quebec	4 924 241	4 200 352	9 124 593	5 014 341	4 278 886	9 293 227	5 464 094	4 911 412	10 375 506
Ontario	7 794 586	3 775 774	11 570 360	7 965 310	4 042 331	12 007 641	8 621 518	4 768 029	13 389 547
Manitoba	959 281	510 719	1 470 000	865 835	496 251	1 362 086	832 839	611 990	1 444 829
Saskatchewan	1 217 977	885 247	2 103 224	1 169 326	1 044 053	2 213 379	1 284 539	1 569 280	2 853 819
Alberta	4 717 389	4 655 649	9 373 038	5 073 851	6 144 574	11 218 425	6 080 995	7 523 132	13 604 127
British Columbia, Yukon and Northwest Territories	3 331 675	2 853 540	6 185 215	4 333 442	3 475 690	7 809 132	4 913 854	3 956 488	8 870 342
Canada	24 705 907	18 316 959	43 022 866	26 123 479	20 945 677	47 069 156	29 189 341	25 229 361	54 418 702

Source: Statistics Canada.

[1] Actual expenditures 1979, preliminary actual 1980, intentions 1981.

Construction firms can also integrate backwards into the resource field.

The possibility of substitutes for aggregates is not likely to occur soon in Canada, although in countries where such resources are scarce other materials such as compressed garbage are being used. The use of lime or cement to stabilize soils could reduce the amount of aggregate fill required on some highway or railway projects.

Traditional markets for building stone have been lost to competitive building materials such as steel and concrete. Modern design and construction methods favour the flexibility offered by use of steel and precast or cast-in-place concrete. For aesthetic qualities not available in other materials, rough or polished stone is used in many modern structures. Monument stone continues to be in demand.

The present structure of the building stone industry in Canada is unlikely to change in the near future. Efforts have been made on behalf of the industry to illustrate to contractors and architects the availability of a wide range of Canadian building stones and their adaptability in modern building design.

There is justifiable concern for the future development, operation, and rehabilitation of pits and quarries in all locations, especially in and near areas of urban development. Rehabilitation of stone quarries for subsequent land use is generally more difficult and costly than rehabilitation of gravel pits.

Although an open-pit mining operation close to residential areas is seldom desirable, nonrenewable mineral resources must be fully and wisely utilized. When urban sprawl has been unexpectedly rapid, conflicts for land use can materialize and potential sources of raw mineral materials for the construction industry can be overrun. Master plans for land use are required to coordinate all phases of development so that mineral exploitation is part of the urban growth pattern.

TABLE 10. CANADA, VALUE OF CONSTRUCTION[1] BY TYPE, 1979-81

	1979	1980	1981
		($ million)	
Building Construction			
Residential	14,267	13,776	15,417
Industrial	2,068	2,565	2,845
Commercial	5,074	6,011	6,870
Institutional	1,831	2,108	2,314
Other building	1,466	1,663	1,743
Total	24,706	26,123	29,189
Engineering Construction			
Marine	235	256	331
Highways, airport runways	3,380	3,510	3,730
Waterworks, sewage systems	1,863	2,000	2,251
Dams, irrigation	174	202	247
Electric power	4,279	4,110	4,802
Railway, telephones	1,621	1,891	2,073
Gas and oil facilities	4,643	6,326	8,320
Other engineering	2,122	2,651	3,475
Total	18,317	20,946	25,229
Total construction	43,023	47,069	54,418

Source: Statistics Canada.
[1] Actual expenditures 1979, preliminary actual 1980, intentions 1981.

TABLE 11. CANADA, VALUE OF CONSTRUCTION WORK PERFORMED[1], BY PRINCIPAL TYPES OF CONSTRUCTION, BY INDUSTRY, 1979-1981

Industry	1979			1980			1981		
	Building	Engineering	Total	Building	Engineering	Total	Building	Engineering	Total
					(millions of dollars)				
Agriculture and fishing	745	406	1,151	830	452	1,282	892	486	1,378
Forestry	25	182	207	26	178	204	33	212	245
Mining, quarrying and oil wells	336	4,869	5,205	440	6,712	7,152	578	8,100	8,678
Construction	177	2	179	193	3	196	223	3	226
Manufacturing	1,677	573	2,250	2,099	660	2,759	2,245	1,070	3,315
Utilities	824	6,486	7,310	1,090	6,846	7,936	1,096	8,728	9,824
Trade	654	16	670	695	27	722	772	30	802
Finance, insurance and real estate	2,644	424	3,068	3,194	368	3,562	3,860	390	4,250
Commercial services	657	9	666	697	13	710	684	13	697
Housing	14,267	-	14,267	13,776	-	13,776	15,417	-	15,417
Institutional services	1,575	23	1,598	1,848	23	1,871	2,032	23	2,055
Government departments	1,125	5,327	6,452	1,235	5,664	6,899	1,357	6,174	7,531
Total	24,706	18,317	43,023	26,123	20,946	47,069	29,189	25,229	54,418

Source: Statistics Canada.

[1] Actual expenditures 1979, preliminary actual 1980, intentions 1981.

Although there is no absolute shortage of aggregate, a shortage of aggregate at reasonable prices could result from growing opposition to the industry. Already large deposits of accessible aggregate material have been removed from the "reserves" category by legislation. Further restrictions could curtail sand and gravel operations in Ontario in about 20 years. Industry has been hesitant to invest in new plant sites, which would increase their reserve base, until the impact of proposed legislation is known.

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TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
29635-1	Limestone, no further processed than crushed or screened	free	free	25	free
30500-1	Flagstone, sandstone and all building stone, not hammered, sawn or chiselled	free	free	20	free
30505-1	Marble, rough, not hammered or chiselled	free	free	20	free
30510-1	Granite, rough, not hammered or chiselled	free	free	20	free
30515-1	Marble, sawn or sand rubbed, not polished	free	4.9	35	free
30520-1	Granite, sawn	free	7.3	35	free
30525-1	Paving blocks of stone	free	7.3	35	free
30530-1	Flagstone and building stone other than marble or granite, sawn on not more than two sides	free	7.3	35	free
30605-1	Building stone, other than marble or granite, sawn on more than two sides but not sawn on more than four sides	5	7.3	10	4.5
30610-1	Building stone, other than marble or granite, planed, turned, cut or further manufactured than sawn on four sides	7.5	11.9	15	7.5
30615-1	Marble, not further manufactured than sawn, when imported by manufacturers of tombstones to be used exclusively in the manufacture of such articles, in their own factories	free	free	20	free
30700-1	Marble, nop	16.4	16.4	40	10.5
30705-1	Manufacturers of marble, nop	16.4	16.4	40	10.5
30710-1	Granite, nop	16.6	16.6	40	11
30715-1	Manufacturers of granite, nop	16.6	16.6	40	11
30800-1	Manufacturers of stone, nop	16.9	16.9	35	11
30900-1	Roofing slate, per square of 100 square feet	free	free	75¢	free
30905-1	Granules, whether or not coloured or coated, for use in manufacture of roofing, including shingles and siding	free	free	25	free

MFN Reductions under GATT (effective January 1 of year given)

Item No.	1980	1981	1982	1983	1984	1985	1986	1987
				(%)				
30515-1	4.9	4.8	4.6	4.5	4.4	4.3	4.1	4.0
30520-1	7.3	7.0	6.8	6.5	6.3	6.0	5.8	5.5
30525-1	7.3	7.0	6.8	6.5	6.3	6.0	5.8	5.5
30530-1	7.3	7.0	6.8	6.5	6.3	6.0	5.8	5.5

TARIFFS (cont'd)

CANADA (cont'd)

Item No.	1980	1981	1982	1983	1984	1985	1986	1987
					(%)			
30605-1	7.3	7.0	6.8	6.5	6.3	6.0	5.8	5.5
30610-1	11.9	11.4	10.8	10.3	9.7	9.1	8.6	8.0
30700-1	16.4	15.4	14.3	13.3	12.2	11.1	10.1	9.0
30705-1	16.4	15.4	14.3	13.3	12.2	11.1	10.1	9.0
30710-1	16.6	15.7	14.8	13.9	12.9	12.0	11.1	10.2
30715-1	16.6	15.7	14.8	13.9	12.9	12.0	11.1	10.2
30800-1	16.9	16.3	15.6	15.0	14.4	13.8	13.1	12.5

UNITED STATES

Item No.		
513.61	Granite, not manufactured, and not suitable for use as monumental, paving or building stone	free
514.11	Limestone, crude, not suitable for use as monumental, paving or building stone	free
514.91	Quartzite, whether or not manufactured	free
515.41	Stone, other, not manufactured and not suitable for use as monumental, paving or building stone	free

		1980	1981	1982	1983	1984	1985	1986	1987
						(%)			
513.21	Marble chips and crushed	4.4	3.8	3.1	2.5	1.9	1.3	0.6	free
515.11	Roofing slate	11.8	11.0	10.3	9.6	8.8	8.1	7.3	6.6

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated 1980, USITC Publication 1011; U.S. Federal Register, Vol. 44, No. 241.

Sulphur

B. BOYD

In 1980, Canada's production of sulphur in all forms, at 7.1 million tonnes (t) ranked third in the world, behind the United States and the U.S.S.R. and ahead of Poland. In terms of exports Canada was first at 7.0 million t, accounting for almost 45 per cent of world trade. Consumption of sulphur-all-forms in Canada ranks fourth in the western world at 1.5 million t.

"Sulphur enters into the manufacture or processing of nearly every industrial product. In the initial stage of consumption, sulphur is generally converted into a secondary product, the most common being sulphuric acid. This sulphur, in the form of acid, element, or sulphite, is consumed by the end-use industry. In the final step, the products of these industries contribute, in turn, countless ...articles..." including "almost everything we eat, wear, or use." - T.H. Janes.

Occurrences of workable deposits of sulphur, in elemental and combined forms, are distributed throughout the world. It is difficult to measure sulphur in terms of firm reserves but it is generally accepted that total world resources are 1,000 to 10,000 times current annual consumption. One-third of the world's sulphur output is recovered from deposits of native sulphur and close to another third is recovered as elemental sulphur from conversion of hydrogen sulphide removed from natural gas and oil. The remainder is recovered from sulphur dioxide gas produced in the roasting of pyrite and smelting of various metal sulphide ores. The sulphur in these cases is recovered as sulphuric acid or liquid sulphur dioxide. Other sources of sulphuric acid which currently account for small quantities of production are gypsum and anhydrite.

World sulphur production in all forms increased marginally in 1980 to 55.2 million t. World consumption however, exceeded production for the second year in a row and is estimated at 57.0 million t, requiring withdrawal from stockpiles in Canada, Poland and the United States.

In 1980, Canadian sales of elemental sulphur reached a new record at 7.4 million t, 17 per cent higher than in 1979. Sales of sulphuric acid and liquid sulphur dioxide increased by 35 per cent to 903 000 t of contained sulphur. When minor sales of pyrite had been added in, total sales amounted to 8.3 million t. Eighty-two per cent of sales were exports of elemental sulphur. Sales exceeded production, thus stockpiles of elemental sulphur were drawn down by more than 1.2 million t to a level of 18.85 million t by year-end.

Properties of sulphur. The element sulphur is 16th in the periodic table and has an atomic weight of 32.06. Its elemental form, known since antiquity as brimstone, is a pale yellow, odourless, brittle solid, insoluble in water, naturally occurring around volcanic vents and in some evaporite series. At standard temperatures and pressure sulphur forms thick tabular orthorhombic crystals with a specific gravity of 2.07. The melting point is 113°C and it will burn at 270°C with a blue flame.

Sulphur occurs more commonly in combined forms of which hydrogen sulphide, pyrite and pyrrohotite are commercially important.

Hydrogen sulphide is a highly toxic and corrosive gas under standard conditions and occurs dissolved in natural gas and in crude oil. The modified Claus process is used to recover elemental sulphur from sour natural gas. H_2S is extracted by absorption into a solution of either diethanolamine, monoethanolamine, hot potassium carbonate, or sulfinol. The solution is heated in a stripper tower where H_2S is evolved. The H_2S passes into a furnace where partial oxidation and reaction occurs as follows:

$$2H_2S + 3O_2 \rightleftharpoons 2H_2O + 2SO_2$$

$$2H_2S + SO_2 \rightleftharpoons 2H_2O + 3S$$

Gas from this furnace enters a condenser-converter series and liquid sulphur is removed in each unit until 95 per cent or more of the original sulphur has been drawn off.

Pyrite (FeS_2, 53.5 per cent sulphur by weight) and pyrrhotite ($Fe_{1-x}S$) are iron sulphides which are widely distributed, and are of commercial importance as sources of sulphur.

Other metal sulphides such as chalcopyrite ($CuFeS_2$), sphalerite $(Zn,Fe)S$, galena (PbS_2) and pentlandite $(Fe,Ni)_9S_8$ are important in Canada as sources of copper, zinc, lead and nickel. There are 14 nonferrous smelters in Canada and some of the sulphur in off gases is recovered at 8 of these. The sulphide ore when roasted at the beginning of the smelting process gives off sulphur dioxide gas. The gas is then either; chilled and compressed to form liquified SO_2 (50.1 per cent sulphur by weight) or, converted over a catalyst to sulphur trioxide (SO_3) and then, with the addition of water, recovered as sulphuric acid (or when there is excess SO_3, as oleum).

Sulphuric acid (H_2SO_4, 32.7 per cent sulphur by weight) is the major reagent of the fertilizer and chemical industries, accounting for 80 per cent of all sulphur consumption. More than half of this acid is produced by burning some 30 million t of sulphur a year; in the process, some 10.5 million kilojoules of heat energy per t[1] of sulphur is released. The recoverable amount of energy is equivalent to about 45 million barrels of oil a year, but only a small fraction is used.

THE CANADIAN SULPHUR INDUSTRY

Canadian sulphur is obtained from three sources: elemental sulphur derived from sour natural gas and petroleum, sulphuric acid and sulphur dioxide recovered from smelter gases and sulphuric acid from pyrite concentrates. Minor tonnages of elemental sulphur are recovered as a byproduct of electrolytic refining of nickel sulphide matte.

In 1980, 89 per cent of Canadian sulphur shipments were in elemental form, mainly from sour gas plants in western Canada but also from the Athabasca oil sands and from oil refineries. Over 1.2 million t of elemental sulphur were drawn from stockpiles to bring shipments of elemental sulphur to 7.4 million t.

Although the H_2S content of sour gas fields ranges as high as 91 per cent by weight, most producing fields contain from 1 to 20 per cent. Sulphur recoveries range from 94.5 per cent for gas plants handling 10 tpd of sulphur, to 99 per cent for plants with 1 300 tpd of sulphur in inlet gas. Due to production and a re-evaluation of natural gas pools the reported reserves of sulphur recoverable from natural gas in Alberta fell from 131.8 million t at year-end 1979 to 114.8 million t at the end of 1980. On the other hand, an estimated 181 million t of sulphur have been classified as reserves in crude bitumen, chiefly from the tar sands near Fort McMurray.

There were 50 sour gas plants operating in Alberta, one in Saskatchewan and 3 in British Columbia in 1980. The nameplate capacity of the 62 units together was 10 million tpy of sulphur. There was 5 725 000 t of sulphur recovered at the Alberta plants, 162 000 t in British Columbia and none from the plant in Saskatchewan. As gas fields are slowly depleted of H_2S the utilization of sulphur recovery units will decrease. Four new plants with a combined capacity of about 180 000 tpy opened in 1980 and these will likely run at close to capacity for several years. No new sour gas plants have been announced for 1981. Hudson's Bay Oil and Gas Company Limited (HBOG) is constructing a 900 tpd sulphur recovery unit as part of a new gas processing plant in the Hanlan-Robb area, due for completion in 1982.

Sulphur production is directly tied to sour natural gas production. In 1981, exports and total sales of natural gas are

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[1] Approximately 9 million Btu per tonne.

TABLE 1. CANADA, SULPHUR SHIPMENTS AND TRADE, 1979 AND 1980

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Shipments				
Pyrite and pyrrhotite[1]				
Gross weight	31 032	..	32 000	..
Sulphur content	13 964	274,879	14 000	345,000
Sulphur in smelter gases[2]	667 265	14,514,847	903 000	22,955,000
Elemental sulphur[3]	6 314 244	159,641,928	7 403 000	414,484,000
Total sulphur content	6 995 473	174,431,654	8 320 000	437,784,000
Imports				
Sulphur, crude or refined				
United States	1 687	583,000	1 755	463,000
West Germany	12	9,000	12	11,000
Total	1 699	592,000	1 767	474,000
Sulphuric acid and oleum				
United States	170 618	7,301,000	18 049	931,000
Exports				
Sulphur in ores (pyrite)				
United States	..	281,000	..	386,000
Total	..	281,000	..	386,000
Sulphur acid and oleum				
United States	139 424	3,086,000	323 768	7,523,000
Other countries	1	2,000	13	26,000
Total	139 425	3,088,000	323 781	7,549,000
Sulphur, crude or refined, nes				
United States	1 239 269	26,600,000	1 434 593	53,008,000
South Africa	480 050	23,018,000	709 979	67,190,000
Brazil	424 227	17,025,000	654 119	58,865,000
Australia	343 354	14,969,000	667 450	53,199,000
Tunisia	141 900	8,142,000	409 593	42,330,000
Taiwan	192 333	9,481,000	290 863	33,001,000
People's Republic of China	244 139	11,974,000	343 195	30,750,000
Morocco	205 760	9,726,000	260 872	27,759,000
South Korea	274 541	12,956,000	251 353	26,534,000
Belgium-Luxembourg	101 382	5,379,000	208 253	22,872,000
Italy	291 841	12,245,000	251 846	21,127,000
New Zealand	247 565	10,385,000	233 649	17,713,000
India	241 175	11,149,000	188 600	17,593,000
France	94 622	3,564,000	185 223	12,575,000
Other countries	632 673	29 698,000	760 521	58,526,000
Total	5 154 831	206,311,000	6 850 109	543,042,000

Source: Statistics Canada; Energy, Mines and Resources Canada.

[1] Producers' shipments of byproduct pyrite and pyrrhotite from the processing of metallic sulphide ores. [2] Sulphur in liquid SO_2 and H_2SO_4 recovered from the smelting of metallic sulphides and from the roasting of zinc-sulphide concentrates. [3] Producers' shipments of elemental sulphur produced from natural gas; also included are small quantities of sulphur produced in the refining of domestic crude oil and synthetic crude oil.

P Preliminary; .. Not available; nes Not elsewhere specified.

TABLE 2. CANADA, SOUR GAS SULPHUR EXTRACTION PLANTS

Operating Company	Source Field or Plant Location (Alberta, except where noted)	H_2S in Raw Gas (%)	Daily Capacity (tonnes)
Amerada Hess Corporation	Olds	11	384
Amoco Canada Petroleum	Bigstone Creek	19	382
Amoco Canada Petroleum	East Crossfield	34	1 757
Aquitaine Company of Canada	Rainbow Lake	4	139
Aquitaine Company of Canada	Ram River	9-35	4 567
Canada-Cities Service, Ltd.	Paddle River		19
CDC Oil & Gas Limited	Brazeau River		42
Canadian Superior Oil Ltd.	Harmattan-Elkton	53	490
Canadian Superior Oil Ltd.	Lonepine Creek	12	157
CanDel Oil Ltd.	Minnehik-Buck Lake		45
Chevron Standard Limited	Kaybob South	19	3 521
Chevron Standard Limited	Nevis	7	260
Dome Petroleum Limited	Cranberry		319
Dome Petroleum Limited	Pembina-Alder		4
Esso Resources Canada	Joffre		17
Esso Resources Canada	Quirk Creek	9	300
Esso Resources Canada	Redwater	3	33
Gulf Canada Limited	Nevis	3-7	295
Gulf Canada Limited	Pincher Creek[1]	10	160
Gulf Canada Limited	Rimbey	1-3	333
Gulf Canada Limited	Strachan	10	943
Home Oil Company Limited	Carstairs	1	72
Hudson's Bay Oil and Gas	Brazeau River	1	110
Hudson's Bay Oil and Gas	Caroline	1	22
Hudson's Bay Oil and Gas	Edsen	2	284.5
Hudson's Bay Oil and Gas	Hespero (Sylvan Lake)	1	16
Hudson's Bay Oil and Gas	Kaybob South (1)	17	1 064
Hudson's Bay Oil and Gas	Kaybob South (2)	17	1 064
Hudson's Bay Oil and Gas	Lonepine Creek	10	283
Hudso[illegible] Bay Oil and Gas	Zama		74
J.S[illegible]nterprises Ltd.	Acadia		0.2
Me[illegible] Explorations Limited	Giroux Lake-Steele		1
Mob[illegible]l Canada, Ltd.	Wimborne	14	168
Norcen Energy Resources	Ferrier		120
PanCanadian Petroleum Limited	Countess		14
PanCanadian Petroleum Limited	Morley		18
Petro-Canada	Gold Creek		43
Petrofina Canada Inc.	Wildcat Hills	4	177
Petrogas Processing Ltd.	Crossfield (Balzac)	31	1 687
Saratoga Processing Company	Savannah Creek (Coleman)	13	389
Shell Canada Limited	Burnt Timber Creek	8-5	497
Shell Canada Limited	Innisfail	14	163
Shell Canada Limited	Jumping Pound	3-5	511
Shell Canada Limited	Rosevear		153
Shell Canada Limited	Simonette River	15	267
Shell Canada Limited	Waterton	18-25	3 066
Steelman Gas Limited	Steelman, Sask.	1	7
Suncor Inc.	Rosevear		84
Texaco Exploration Company	Bonnie Glen		15
Texasgulf Inc.	Okotoks	36	459
Texasgulf Inc.	Windfall	16	1 175
Westcoast Transmission	Fort Nelson, B.C.		1 100
Westcoast Transmission	Pine River, B.C.		1 055
Westcoast Transmission	Taylor Flats, B.C.	3	325
Western Decalta Petroleum	Turner Valley	4	24
Total daily rated capacity December 31, 1980			28 674

Sources: Compilation by **Oilweek**, "H_2S in Raw Gas" figures from Alberta Energy Resources Conservation Board publications.

[1] To shut down in 1981.

expected to decrease so that in spite of capacity expansions, sulphur production will likely fall slightly.

Sulphur can be recovered at 12 of Canada's operating oil refineries but in 1980 much of the capacity was unused. About 39 000 t of elemental sulphur was recovered from domestic crude oil (not including the tar sands) and perhaps three times that amount was recovered from foreign crude oil (not counted as domestic production).

The Athabasca oil sands in northern Alberta are not only a source of crude petroleum, but with a sulphur concentration averaging 4.8 per cent in bitumen, are an important source of elemental sulphur. In 1980, 287 000 t of sulphur were recovered at the two operating oil sands plants near Fort McMurray.

TABLE 3. CANADIAN REFINERY SULPHUR CAPACITIES, 1980

Operating Company	Location	Daily Capacity (tonnes)
Gulf Canada Limited	Edmonton, Alberta	103
	Port Moody, B.C.	25
	Clarkson, Ontario	40
	Port Tupper, N.S.	40[1]
Husky Oil	Prince George, B.C.	5
Imperial Oil	Edmonton, Alberta	36
	Dartmouth, N.S.	40
	Sarnia, Ontario	103
	Vancouver, B.C.	20
Irving Oil	Saint John, N.B.	200
Laurentide Chemicals & Sulphur Ltd.	Montreal, Quebec	300
Newfoundland Refining Co. Ltd.	Come-by-Chance, Nfld.	194[1]
Shell Canada	Shellburn, B.C.	15
	Oakville, Ontario	50
	Sarnia, Ontario	31
Suncor	Sarnia, Ontario	10
Texaco Canada	Nanticoke, Ontario	8
Total 1980		986

Sources: **Oilweek, Chemical Economics Handbook.**

[1] Not operational in 1980.

The plant opened in 1967 by Great Canadian Oil Sands Limited (GCOS) came under control of Suncor Inc. in August 1979 with the amalgamation of GCOS and Sun Oil Company. In 1980, the plant operated at close to its 45 000 barrel per day capacity most of the year, and as a result nearly 100 000 t of sulphur was recovered.

The Syncrude Canada Ltd. plant, which started operation in 1978, operated most of the year at about 90 000 barrels per day and produced nearly 200 000 t of sulphur in 1980.

A third project, proposed by a consortium, The Alsands Group, would have a daily capacity of about 140 000 barrels of synthetic fuel and would be expected to provide 300 000 to 400 000 tpy of sulphur. This project has been postponed however, and will not likely reach full production before 1988.

Other projects which have been proposed would develop the Cold Lake heavy oil deposits with sulphur concentrations averaging 4.4 per cent, the Peace River deposit at 6 per cent sulphur and the Wabasca deposit at 6.1 per cent sulphur.

Two recent gas strikes, Shell Whiskey and Chevron Shell Moose, south of Calgary gave H_2S concentrations of 7 to 40 per cent. Such wells and other fields such as Panther River, known to be high in hydrogen sulphide could some day be developed as sulphur sources with recovery costs below those at Frasch mines.

Recovery of elemental sulphur during production of fuel or energy from coal may be possible at the Hat Creek deposit in British Columbia, where sulphur content averages 0.5 per cent.

Excess sulphur has been stockpiled in Alberta since the late 1960s until stocks peaked at 21.0 million t in July 1979. Thereafter withdrawals have exceeded additions and sulphur stored in Alberta amounted to 18 197 000 t at year-end 1980. Stocks should represent a potential supplemental source of sulphur for shipment until about 1988-92.

Elemental sulphur is produced as an orange clear liquid at about 120°C. During the early 1970s, when supply far exceeded demand in Canada, the liquid sulphur was piped to enclosures or vats where layers of the molten material were allowed to cool and solidify. As each layer hardened the walls of the vat were raised and new layers of

TABLE 4. CANADA, PRINCIPAL SULPHUR DIOXIDE AND SULPHURIC ACID PRODUCTION CAPACITIES, 1980

			Annual Capacity	
Operating Company	Plant Location	Raw Material	Sulphuric Acid[1]	S. equiv.
			(000 tonnes)	
Aluminum Company of Canada, Limited	Arvida, Que.	Elem. S.	80	26
Allied Chemical	Valleyfield, Que.	SO_2 zinc conc.	140	46
Brunswick Mining and Smelting Corp. Ltd.	Belledune, N.B.	SO_2 lead-zinc	160	52
Canadian Electrolytic Zinc	Valleyfield, Que.	SO_2 zinc conc.	210	69
C-I-L Inc.	Beloeil, Que.	Elem. S.	65	21
	Copper Cliff, Ont.[2]	SO_2 pyrrhotite	900	294
	Copper Cliff, Ont.[2]	SO_2 copper	Liquified SO_2	45
NL Chem Canada Inc.	Varennes, Que.	Elem. S.	45	15
Falconbridge Nickel Mines Limited	Sudbury, Ont.	SO_2 pyrrhotite	285	93
International Minerals & Chemical Corporation (Canada) Limited	Port Maitland, Ont.	Elem. S.	250	82
Gaspé Copper	Murdochville, Que.	SO_2 copper	245	80
Sulco Chemicals Ltd.	Elmira, Ont.	Elem. S.	35	11
Texasgulf Inc.	Kidd Creek, Ont.	SO_2 zinc conc.	190	62
Subtotal Eastern Canada			2 605	897
Border Chemical Company Ltd.	Transcona, Man.	Elem. S.	150	49
Cominco Ltd.	Kimberley, B.C.	SO_2 pyrrhotite	300	98
	Trail, B.C.	SO_2 lead-zinc	430	141
	Trail, B.C.	SO_2 lead-zinc	Liquified SO_2	40
Esso Chemical Canada	Redwater, Alta.	Elem. S.	515	168
Gulf Canada Limited	Rabbit Lake, Sask.	Elem. S.	45	15
Inland Chemicals Ltd.	Fort Saskatchewan, Alta.	Elem. S.	125	41
	Prince George, B.C.	Elem. S.	35	11
Sherritt Gordon Mines Limited	Fort Saskatchewan, Alta.	Elem. S.	180	59
Western Co-operative Fertilizers Limited	Calgary, Alta.	Elem. S.	180	59
	Medicine Hat, Alta.	Elem. S.	190	62
Subtotal Western Canada			2 150	743
TOTAL			4 755	1 640

Source: Energy, Mines and Resources Canada.
[1] 100% H_2SO_4; [2] Sold to Inco Limited in 1981.

sulphur added until "blocks" of sulphur were created which covered several acres and were up to three stories high.

For shipment, the elemental sulphur in the storage blocks was ripped with bulldozers and loaded with power shovels or front-end loaders into rail cars. The loading, transport, unloading and storage of lumps of broken material, bulk sulphur, created dust problems which were a health hazard and, due to the risk of explosion, a safety concern. Stationary and in-situ melters are now employed to produce liquid sulphur from the blocks. Current melting capacity is about 300 000 t per month.

Sulphur is, in some cases, shipped in liquid form. Tank cars are cheaper to load than hopper cars provided the sulphur can be loaded as it is produced. A skin of solid sulphur several centimetres thick forms on the inside surface of the tanks and creates an excellent insulator so that most of the sulphur remains liquid even at ambient temperatures of -30°C or lower. Unloading requires steam tracing to melt the insulation layer. Liquid shipments are not used to reach offshore markets but dominate trade within North America.

It is not possible to ship liquid sulphur to offshore markets and bulk shipments are not allowed because of dust problems. Formed sulphur, either slates, granules or prills now dominate the market. Slating involves passing a ¼ to ½ inch layer of liquid sulphur along a long water cooled conveyor belt. The layer hardens and, at the end of the conveyor, breaks into "slates" some 3 to 6 centimetres across. Slated sulphur is easily handled with front-end loaders, shovels and conveyors. Slating capacity in Alberta is about 5 million t, much of which is being replaced by granulating and prilling. By year-end 1981, about 60 per cent of offshore exports are expected to be in granule or prill form.

In Canada, four processes account for nearly all of the production of granules or prills. Two processes use water to quench sprays of molten sulphur, and produce relatively lumpy granules in a large range of sizes. The product is screened and undersize and oversize are returned to the granulators, liquified and reprocessed. These wet processes, the Fletcher and the P.V. Commodity Systems, require relatively low initial capital investment and can be scaled to fit nearly any size sour gas plant. The other two processes use air, blown up through towers, to quench counter-current sprays of molten sulphur and produce dimpled spheroids of fairly consistent size. These "dry processes", by Ciech of Poland and Procor Limited (U.S. parent Trans Union Corporation) (Procor GX granulators), require high initial capital investment and are suited to large scale applications.

The Fletcher system is employed by Westcoast Transmission Company Limited at Fort Nelson and at Taylor, British Columbia

TABLE 5. CANADA, SULPHUR SHIPMENT AND TRADE, 1970, 1975-80

	Shipment				Imports	Exports	
	Pyrites[1]	In Smelter Gases	Elemental Sulphur	Total	Elemental Sulphur	Pyrites[2]	Elemental Sulphur
	(tonnes)				(tonnes)	($)	(tonnes)
1970	159 222	640 360	3 218 973	4 018 555	48 494	1,226,000	2 711 069
1975	10 560	694 666	4 078 780	4 784 006	14 335	170,000	3 284 246
1976	15 377	705 327	4 029 427	4 750 131	15 717	152,000	3 719 992
1977	12 060	736 009	5 207 028	5 955 097	14 065	212,000	4 291 032
1978	4 602	676 278	5 752 208	6 433 088	8 130	57,000	4 984 546
1979	13 964	667 265	6 314 244	6 995 473	1 699	281,000	5 154 831
1980P	14 000	903 000	7 403 000	8 320 000	1 767	386,000	6 850 109

Source: Statistics Canada; Energy, Mines and Resources Canada.
[1] See footnotes for Table 1. [2] Quantities of pyrites exported not available.
P Preliminary.

where capacities are about 330 and 500 tpd respectively. An 800 tpd plant is under construction at Pine River, British Columbia. Real International Marketing Ltd. is installing a 1 000 tpd Fletcher granulator at Prince Rupert, British Columbia, expected to start operation in 1981. A P.V. Commodity Systems Ltd. 1 500 tpd granulator is in operation at PVC's Strachan gas plant in Alberta.

The Procor GX pelletizer was chosen to serve combined production from Syncrude and Suncor working in the oil sands near Fort McMurray, Alberta. In late 1980, 400 tpd capacity was operational and planned expansions will bring capacity to 800 tpd in 1981 and to 2 000 tpd sometime later. There are two other Procor GX granulators: a 400 tpd plant operated by Shell Canada Limited at Harmattan, and a 1 160 tpd plant operated by Texasgulf Inc. and Windfall, both in Alberta.

The first of five prilling units designed by Ciech of Poland for use in Alberta came into operation in 1980. At Strachan, Gulf Canada started a 1 000 tpd prilling tower in February 1980. Shell Canada Resources Limited at Waterton, and Aquitaine at Ram River both plan to bring three 300 tpd prilling towers on-stream in 1981. Hudson's Bay Oil and Gas is constructing a 1 300 tpd tower to serve the Kaybob I and Kaybob II gas fields beginning in 1981. In addition, a Ciech prilling tower is planned for the Hanlan-Robb project due to come on-stream in 1982.

Sulphur transportation Bulk liquid and some formed sulphur are railed and trucked from the points of production to destinations in North America. The sales are negotiated between producer and consumer for both long-term contracts and spot shipments. Exports to the United States had been fairly steady at between 1 million t and 1.2 million t from 1974 to 1979. Seventy per cent of the shipments went to only four states. Idaho alone took a full third and Illinois and Iowa each took 10 to 15 per cent. The fastest growing market is Florida which required no sulphur from Canada before 1978 yet took 121 000 t in 1979, and imported more in 1980.

The Canadian market for elemental sulphur amounts to some 850 000 tpy, half of which remains in Alberta for the manufacture of fertiliser. Transportation by truck, of liquid sulphur, serves a significant part of this market.

TABLE 6. CANADIAN EXPORT MARKETS FOR SULPHUR, 1980

Country or Area	Exports	Per cent of Total
	(million tonnes)	
United States	1.43	20.8
Europe	.94	13.7
South Africa	.71	10.4
Brazil	.65	9.5
Australia	.67	9.8
South Korea	.25	3.6
New Zealand	.23	3.4
People's Republic of China	.34	5.0
India	.19	2.8
Others	1.44	21.0
Total	6.85	100.0

Source: Statistics Canada.

In 1980, 5.3 million t of sulphur were railed to loading terminals in Vancouver for export "offshore", that is outside North America. All of the sulphur was formed, either as slates, prills or granules and shipped in hopper cars. Rail shipment to the port is undertaken by Sultran Ltd. which was established by sulphur producers in 1976 to negotiate with the railways, and to co-ordinate the movement of sulphur by make-up and unit trains for offshore export. In 1980, Sultran arranged the purchase of 680 new rail cars which, when delivered in 1981, will raise shipping capacity to Vancouver to 6 million tpy.

Shipments through Thunder Bay, Ontario for offshore markets in 1980 approached 150 000 t and shipments of prilled sulphur, via Prince Rupert, British Columbia reached 100 000 t, after initial minor shipments in 1979.

More than half of the sulphur exported offshore is handled by Cansulex Limited, a marketing organisation which represents 23 companies that collectively account for 65 per cent of Alberta's sulphur production capability.

Metallic sulphide sources. In Canada the use of metallic sulphides for their sulphur content dates back to 1866. Early operations consisted essentially of roasting pyrite for direct manufacture of sulphuric acid. In the 1920s the use of base-metal smelter gases for the manufacture of byproduct H_2SO_4 began near Sudbury, Ontario, and at Trail, British Columbia. Virtually all Canada's sulphur production was from metallic sulphides prior to 1951, when the first sour gas sulphur recovery plant was built.

Smelter gases. Effluent gas, from smelting sulphide ores, contains from 1 to 12 per cent sulphur dioxide (SO_2). Recovery of SO_2 includes processes for cleaning, cooling and concentrating the gas. Concentrated SO_2 is then used directly for the manufacture of H_2SO_4 via the contact-acid process. Also, as much as 90 000 tpy (45 000 t sulphur content) of liquid SO_2 is produced for use as a processing agent in a variety of applications, mainly in the pulp and paper industry. Some SO_2 is used for the manufacture of oleum (fuming sulphuric acid, $H_2S_2O_7$).

The largest H_2SO_4 complex in Canada is that of C-I-L Inc. at Copper Cliff, Ontario. The company operates three acid plants that have a combined annual capacity of 900 000 t of H_2SO_4 based on SO_2 gas from Inco Limited's iron ore recovery plant. In addition, C-I-L has a liquid sulphur dioxide plant at Inco's nearby Copper Cliff smelter. Acid produced at Copper Cliff is shipped by a 56-car, unit-train about 760 km to C-I-L's fertiliser works near Sarnia, Ontario. The company also ships to depots at Niagara Falls, Ontario; Sorel, Quebec; Chicago, Illinois; Cleveland, Ohio; and River Rouge, Michigan.

Subsidiaries of Noranda Mines Limited produce smelter acid at three localities: Gaspé Copper Mines, Limited's 245 000 tpy plant at Murdochville, Quebec; Brunswick Mining and Smelting Corporation Limited's 125 000 tpy plant at Belledune, New Brunswick; and the Canadian Electrolytic Zinc Limited's zinc concentrate roasting facility at Valleyfield, Quebec, with a capacity of 120 000 tpy.

Allied Chemical Canada, Ltd., produces sulphuric acid from the roasting of zinc concentrates supplied under an agreement with Canadian Electrolytic Zinc Limited whereby Allied retains the acid for its own use and delivers the zinc calcine to Canadian Electrolytic Zinc's nearby refinery.

Cominco Ltd.'s sulphuric acid capacity at Trail, British Columbia, based on its lead-zinc smelter, was increased 30 per cent in 1975 to 430 000 tpy with the replacement of the older units by a single plant. Further expansion is planned for the early 1980s. Acid capacity at the company's Kimberley plant is 300 000 tpy. Much of the acid produced is used by Cominco in the manufacture of fertilisers.

Texasgulf Canada Ltd.'s, Timmins, Ontario zinc plant has a sulphuric acid capacity of 190 000 tpy. In 1981 an acid plant connected with the copper smelter will come into operation and raise acid capacity to 410 000 tpy.

Falconbridge Nickel Mines Limited brought a 285 000 tpy acid plant on-stream in 1979, in conjunction with the new electric smelter. The sulphuric acid produced is marketed by C-I-L Inc.

TABLE 7. CANADA, SULPHURIC ACID PRODUCTION, TRADE AND APPARENT CONSUMPTION, 1970, 1975, 1976-80

	Production	Imports	Exports	Apparent Consumption
		(tonnes - 100% acid)		
1970	2 475 070	9 948	129 327	2 355 691
1975	2 723 202	154 020	225 402	2 651 820
1976	2 842 431	39 537	349 826	2 532 142
1977	3 140 340	6 634	293 994	2 852 980
1978	3 260 846	107 766	205 166	3 163 446
1979	3 666 080	170 618	139 425	3 697 273
1980P	4 295 366	18 049	323 781	3 989 634

Sources: Statistics Canada; Energy, Mines and Resources Canada.
P Preliminary.

Production of sulphuric acid is also carried out at plants burning elemental sulphur. The majority of this production takes place at fertilizer plants in western Canada: at Redwater, Fort Saskatchewan, Calgary and Medicine Hat, Alberta and Prince George, British Columbia. Secondary in importance are fertilizer producers in eastern Canada, the chemical industries and uranium ore processors, from west to east at Transcona, Manitoba, Port Maitland and Elmira, Ontario, and Varennes, Beloeil, Valleyfield and Arvida, Quebec.

Altogether Canadian annual capacity for production of sulphuric acid from all sources is 4.7 million t.

Trends. Shipments of pyrites recovered in 1979 and 1980 after a record low in 1978. Most of the material was exported to the eastern United States. Some pyrite and pyrrhotite was produced by Cominco in British Columbia, but because it was burned "on-site" the quantity is not reported. As recently as 1970 shipments were ten times the 1980 level and capacity to mine pyrite is readily available. With the rapid rise in sulphur prices to a level, in constant dollars, similar to prices in the 1960s, the increased use of pyrite for its sulphur content is possible.

Recovery of sulphur dioxide from smelter gases reached a new high in 1980. The metals market was depressed in 1980 but sulphuric acid production from this source is expected to increase significantly when markets improve.

The trend of ever-increasing annual shipments of elemental sulphur should end in 1982 as the rate of withdrawal from stockpiles reaches an optimum level. Thereafter, investment in additional sulphur melting equipment and transportation equipment will not be justified because of the expected short life of remaining stockpiles.

Imports of sulphur were negligible for the second year in a row. A turnaround in U.S. export prices would likely be necessary before imports by Canada would be significant.

EXPORT MARKETS

In 1980, Canadian sulphur exports increased to the five largest markets: United States, Europe, South Africa, Brazil and Australia. Among the five, market share evened out somewhat as the United States share dropped from 24 per cent to 20.8 per cent, Europe's share dragged from 15 per cent to 13.7 per cent and the other three all increased market share to closer to 10 per cent. The ideal situation of selling significant amounts of sulphur on nearly all of the continents of the world, and at a profitable price, has been approached and offers the best security for the Canadian industry.

TABLE 8. CANADA, AVAILABLE DATA ON CONSUMPTION OF SULPHURIC ACID BY INDUSTRY, 1978 AND 1979

	1978	1979
	(tonnes - 100% acid)	
Industrial chemicals[1]	2 185 631	2 585 084^e
Smelting and refining	285 787^e	287 188^e
Pulp and paper mills	253 421	275 429
Uranium ore processing	198 993	210 618
Mining^e	49 900	49 300
Miscellaneous chemical industries	77 113	44 845
Manufacturers of soaps and cleaning compounds	22 850	23 507
Petroleum refineries	22 463	21 998
Manufacturers of plastics and synthetic resins	16 669	17 144
Wire and wire products manufacturers	9 287	10 971
Iron and steel mills	9 486	8 440
Manufacturers of miscellaneous electrical products	5 352	6 062
Metal stamping, pressing and coating industry	3 936	3 039
Motor vehicle parts and accessories manufacturers	2 900	2 800^e
Manufacturers of mixed fertilizers	1 107	1 198
Miscellaneous industries[2]	9 132	15 505
Total	3 154 017	3 563 128

Source: Statistics Canada.
[1] Total includes consumption of "own make" or "captive" sulphuric acid. [2] Miscellaneous industries include synthetic textiles, other petroleum and coal, mineral wool, starch and glucose, vegetable oils, sugar refining and municipal water works.
^{e} Estimated.

CONSUMPTION

Apparent consumption in 1979 and 1980 averaged over 856 000 t of elemental sulphur in Canada. In addition, 815 000 t sulphur equivalent from smelter gases was consumed in Canada in 1980. About 1.3 million t of the total 1.7 million t consumed was in the form of sulphuric acid at some stage.

The largest consuming sector was industrial chemicals including phosphatic fertilizers. To serve the sulphuric acid requirements of this sector some 450 000 t of elemental sulphur was burned, and nearly 400 000 t sulphur equivalent was shipped, as acid, from acid plants adjacent to non-ferrous smelters.

The second most important consumer was the pulp and paper industry which took over 300 000 t of elemental sulphur, between 30 000 t and 50 000 t sulphur equivalent as sulphur dioxide, and over 100 000 t sulphur equivalent as sulphuric acid.

Uranium ore processing and other metal recovery accounted for the use of about 180 000 t sulphur equivalent as sulphuric acid. Other industries using significant amounts of sulphur or sulphuric acid were petroleum refining, plastics, rubber products, soaps, and food processing.

WORLD REVIEW

Sulphur supplies tightened sharply during the latter half of 1978 after almost a decade of surpluses. The situation continued in 1979, and in 1980 was exacerbated by the outbreak of war between Iran and Iraq. About one million tpy was removed from trade by the interruption in shipping and longer-term effects will result from the destruction of sulphur recovery units in Iran. The largest source of sulphur in the region, the Mishraq mine in Iraq, has not been damaged but shipment to markets remained a problem.

In Iran, natural gas production and export were severely reduced. As a result, the U.S.S.R. has been receiving less natural gas and subsequently had to reduce re-export of natural gas, notably to Poland. With lower supplies of natural gas, Frasch production in Poland has been constrained and expansions in production have been delayed.

Morocco plans to continue building phosphate fertilizer plants throughout the decade and forecast sulphur requirements will rise from about 570 000 t in 1980 to 1.6 million t by 1990.

Borregaard A/S of Norway is planning to expand at Sarpsborg using pyrite from the Hjerkinn mine to raise sulphuric acid capacity by 300 000 tpy by 1983.

TABLE 9. WORLD PRODUCTION OF SULPHUR IN ALL FORMS, 1979

	Elemental	Other[1]	Total
	(000 tonnes)		
United States	10 427	2 429	12 856
U.S.S.R.	3 900	5 810	9 710
Canada	6 314	681	6 995
Poland	4 887	206	5 093
Japan	1 189	1 629	2 818
France	2 125	168	2 293
Mexico	2 120	110	2 230
West Germany	1 044	767	1 811
Spain	16	1 127	1 143
Iraq	762	-	762
South Africa	39	587	626
Italy	65	506	571
Finland	6	411	417
Sweden	20	264	284
Iran	244	-	244
Other countries	1 915	5 061	6 976
Total	35 073	19 756	54 829

Source: British Sulphur Corporation Limited, Statistical Supplement, January/February 1981.

[1] Sulphur in other forms includes sulphur contained in pyrites and contained sulphur recovered from metallurgical waste gases mostly in the form of sulphuric acid.

- Nil.

In Spain, Fosforico Espanol S.A. plans by 1982 to add a 300 000 tpy sulphuric acid plant based on local pyrites to the existing 1 330 000 tpy plant at Huelva. Soc. Espanola de Fabricaciones Nitrogenadas SA (SEFANITRO) is planning a 270 000 tpy addition to the acid plant at Luchana.

In Cyprus, Hellenic Mining Co. Ltd. is constructing a 180 000 tpy sulphuric acid plant based on local pyrite. In India, a 240 000 tpy sulphuric acid plant based on pyrite is planned for Amjore.

The United States is the largest producer of sulphur: 11 839 000 t in 1980. Over half of its production, 6 390 000 t of elemental sulphur, is "voluntary" from Frasch-type mines located around the Gulf of Mexico. Recovery from natural gas and oil refining accounts for another 4 046 000 t and is also in elemental form. Remaining production of 1 403 000 t is byproduct recovery, mainly as sulphuric acid and sulphur dioxide. Production in 1980 was 1 796 000 t less than apparent consumption and, with exports running at close to 1.8 million t; the United States imported 2.5 million t, mainly from Canada and Mexico. In addition, stocks were drawn down to the lowest level since 1973. The Caillou Island mine of Freeport Minerals Company came into production in October, and should raise the total Frasch production in 1981.

Mexican sulphur production, which is 95 per cent elemental, increased 0.9 per cent from the 1979 level to 2 250 000 t. Domestic consumption, which has grown rapidly during this decade, was about 0.8 million t in 1980. Exports were 1.1 million t, 5 per cent lower than in 1979 and well below the peak year 1974. Recovery to 1979 levels of production and exports is likely in 1981 with the opening of the Coachapa mine. The United States is the principal destination of Mexican sulphur.

Production of elemental sulphur in 1980 from the Lacq sour natural gas field in France was 2 million t, a production plateau reached in 1969. Exports fell by 17 per cent from the 1979 level, due to increased domestic demand.

Elemental sulphur production from sour gas and oil refineries in the northern part of the Federal Republic of Germany was maintained at 1 million t, as in 1979, following two years of production at 850 000 tpy.

Polish production recovered somewhat in 1980, to 5.2 million t sulphur-all-forms, up 1.8 per cent from 1979 but still below the 5.5 million t achieved in 1978. Exports from Poland have been progressively directed more to other communist countries over the past three years, especially to meet increases in demand in the U.S.S.R.

OUTLOOK

In 1980, the United States imported 1 514 999* t of elemental sulphur, 17 085* t sulphur equivalent of pyrite, 21 123* t sulphur equivalent of sulphur dioxide, and 126 248* t sulphur equivalent of sulphuric acid from Canada. In 1981, all of these figures are expected to increase as United States production fails to keep up with growth in demand.

As one of the earth's most abundant elements, no ultimate shortage of sulphur is foreseeable; however, an examination of the likely rates of development of various sources provides a less-assuring outlook for the more immediate future.

The elasticity of demand for sulphuric acid is low in the short- to medium-term and the only substitution possible, for many firms, is the choice of burning sulphur or pyrites, or purchasing byproduct acid. The lead time for changing sources of acid is long, since investment in pyrite or sulphur furnace represents a large capital commitment. The "locked-in" feature of the consumers, coupled with the large proportion of non-voluntary byproduct sulphur, has led to great swings in price in response to relatively small changes in supply or demand and an inability for the producers or consumers to adjust to changes in market conditions.

During the early 1970s the new byproduct sulphur from sour gas in Alberta pushed the world supply curve beyond the demand curve. Delivered prices fell below the cost of transportation as producers sought to gain market share by taking losses. From a Canadian viewpoint, demand caught-up with supply in 1979 when stockpiles peaked and subsequently began to decrease. The price peaked in mid-1980 and the bulk of offshore sales were in the range $95 to $115 fob Vancouver, as a balance between supply and demand was established based on steady withdrawals from stockpiles to supplement production. The international price structure established in that state of balance gave adequate return to the Frasch producers and encouraged remelting of the stockpiles in Alberta. The cushion supplied by the stockpiles should promote stability in the price unless demand falls below production or until stockpiles are depleted.

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* U.S. import figures

Although Canada is the world's largest exporter of sulphur, currently holding a 39 per cent share of total trade, its impact on world sulphur markets is expected to decline. Production of elemental sulphur from sour natural gas peaked in 1973 at 7.2 million t and output in 1980 was 18 per cent less than that figure. Several of the major plants are recycling operations, i.e., sulphur is stripped from the gas and the gas returned to the reservoir. Output from these plants is now tapering off, and considering the reserve picture for the others, a reduction to about one-half of the peak output from existing plants is expected by 1985. Replacement of part of this production capability through new discoveries and extensions to reserves will occur. However, a reversal in the downtrend during the next decade is unlikely. Declining production will be offset by rising withdrawals from stocks, and annual shipments should level off at 6.5 to 7.0 million t.

Estimates of annual production of sulphur from tar sands by 1985 is 400 000 t. Sulphur produced from smelter gases is expected to reach 1 million t contained in sulphuric acid by 1985. In balance, output of sulphur from all sources is not expected to surpass the 1973 peak until the next decade.

United States Frasch output in 1980 was 20 per cent below the 1974 record of 8.0 million t. Production costs have tripled in recent years because of natural gas price rises and increasing labour and material costs. Despite a trend of improving prices, it seems clear that the numerous mine closures during the past seven or eight years are likely to be permanent. The string of closures is symptomatic of a net decline in reserves. Of 38 mines developed since the inception of the industry, only 10 remain in operation. It now seems optimistic to expect much more than 5.0 million t annual output by 1985. Shipments from stocks reduced them from 4 million t at the end of 1979 to 3 million t at the end of 1980. Sulphur produced from oil, gas, pyrite and smelters could expand to 7.0 million t contained sulphur by 1985, but this would be insufficient to alter the recently developed position of the United States as a net importer of sulphur.

Projections of annual recovery of sulphur from the Overthrust Belt in the United States range from about 1 million t based on reserves and planned projects to about 4 million t based on undiscovered and unmeasured accumulations of gas thought to exist in the same geological formation. In the 1960s, the level of knowledge of an equivalent formation in Alberta was similar to the current information on the Overthrust Belt. Production of sulphur in Alberta increased rapidly over about five years and peaked in 1973. Taking development of the situation in Alberta as a model, peak production would come about in the Overthrust Belt in the early 1990s. Furthermore, if only discovered resources are taken into account, the production cycle would peak even earlier and at a level below 2 million tpy. Under those conditions the United States could become heavily dependent on imported sulphur by the end of this decade. Stockpiles remaining in Alberta would become a very valuable asset.

An alternate projection by the United States Bureau of Mines indicates possible recovery of sulphur from natural gas increasing from 1.7 million t in 1980 to 8 million t in 2000. It also projects recovery of sulphur and sulphuric acid from coal-fired electricity generating stations, synthetic fuels, petroleum refining, and smelting of sulphide ores equivalent to 14 million t of sulphur, in the same time frame, up from 3.7 million t in 1980.

The more optimistic USBM projection indicates self-sufficiency in sulphur to the year 2000 if new uses for sulphur are not included in demand. Given the inelasticity of demand for sulphur and inability of producers to adjust to changes in price both projections promise many opportunities for profitable disposal of the stockpiles located in Alberta.

Although there may be scope for sulphur exploration and development in Mexico, present Frasch operations are experiencing technical difficulties in addition to cost constraints similar to those affecting United States operators. Except for the all-time high of 2.3 million t in 1974, production has varied between 1.2 and 1.8 million t for much of its 25-year history. Mexico's oil and gas reserves, which are proving to be very large, appear to be the most likely source of expanded sulphur production in the country. However, overall sulphur output is not expected to advance significantly until after 1985.

Sulphur production in France from sour natural gas is expected to decline to 1.5 million t by 1985.

In Poland a new mine, planned to open by 1985, will have an annual capacity of 1.1 to 1.2 million t. In the meantime, however, two of the existing mines have production capabilities declining at the rate of 100 000 tpy. The net gain in Polish production by 1985 would only be 500 000 t and much of this will be required by communist bloc countries.

An additional 500 000 tpy from Iraq planned for 1982 and expansions in Iran have been postponed because of the conflict between these two countries. Late in the 1980s, as much as 3 million t could come from these countries which in 1980 produced 720 000 t between them.

By 1985, Saudi Arabia could be exporting 1.2 million tpy from planned and operating projects. The whole amount would be new to the international market since all of current production is vatted and plays no part in meeting present demand.

Coke oven gases generally contain some hydrogen sulphide, the quantity depending upon the sulphur content of the coal being carbonized. Ordinarily the H_2S is removed in "iron oxide boxes" but it can also be recovered and converted to elemental sulphur.

In response to the demand for increasing amounts of clean fuel, numerous research projects have been initiated over the years with the aim of developing high-quality, pollution-free gas from coal. Middle East oil supply cutbacks since 1973 and rapidly rising prices have given further impetus to gasification projects and oil shale studies. The effect of these projects will not be felt before 1990 and it is nearly impossible to forecast sulphur recovery.

Despite the fact that pollution-abatement sulphur will become more important, its impact, for several reasons, is proving to be less dramatic than earlier predictions suggested. For sulphur removal from electric utility stack gases, the largest source of pollution-sulphur, economic and technological considerations weigh in favour of a scrubbing process that will result in an impure gypsum waste product. Advances in acid-producing technology could result in decisions to install acid capacity where the return to a plant covers the higher cost of acid production relative to limestone scrubbing. However, costs of abatement, even with limestone scrubbing, exceed $100 per ton of H_2SO_4 equivalent for most plants; a third alternative, that of using clean coal, is likely to become attractive. In light of energy supply limitations, attention has been focussed on conservation which will moderate growth in fuel consumption, the major source of sulphur emissions.

Under the influence of the foregoing, a period of tight world supply of sulphur is likely to continue. Shipments from reserve stocks in the United States and some remelting in Canada could ease the situation somewhat, but tight supply is likely to prevail until Polish elemental sulphur and European pyrite capacity can be increased. In the meantime, sulphur supplies for phosphate fertilizer manufacture could become a problem, eventually affecting food supply, especially in sulphur deficient countries.

Demand. Recovery in world industrial output is not expected to be dramatic in the medium-term, although the fertilizer sector is expected to continue to show at least modest growth.

For the longer-term, fertilizer manufacture, under the stimulus of world food requirements and the expansion of modern agriculture practice in Asia, Africa and Latin America, should continue to consume a growing portion of sulphur output. Many observers interpret growing substitution of hydrochloric and other acids for sulphuric acid in the pigment, steel pickling and oil-refining sectors as presaging an overall moderation of sulphur consumption growth. Such a view may be too pessimistic. Sulphur's role in the manufacture of substitute reagents must be taken into account; for example, 3 t of H_2SO_4 are needed to produce 1 t of HF. Also, in addition to conventional fertilizer use, attention has been drawn in recent years to sulphur's important role as a plant nutrient and to sulphur deficiencies in the soil over broad areas throughout the world. An area of growth in the "other uses" category is that of uranium production. Uranium ore leaching requires 30 to 50 t of sulphuric acid per t of uranium produced, plus additional acid indirectly in the manufacture of hydrofluroic acid and other chemicals used in processing. Demand for sulphur contained in acid for world uranium production in 1975 was an estimated 350 000 t. By the year 2000, annual requirements are expected to exceed 2 million t. Ore and tailings leaching in base-metal production, and anticipated developments in hydrometallurgy are other consumption areas with high growth potential. Several new uses for elemental sulphur, based on attractive engineering properties, have been under development in recent years. Although some of these are fairly sensitive to sulphur prices, uses such as sulphur-asphalt road-surfacing mixtures could become important. In summary, the future of a reagent so widely available, cheap and versatile as sulphur, seems assured. It would appear that the historical sulphur demand growth of 4.5 per cent a year will be maintained over the medium- to long-term.

PRICES

Canadian sulphur prices quoted in **Alberta Energy Resources Industries** monthly statistics December, 1980

	($)
Sulphur elemental, fob plant, tonne	72.47
Canadian sulphuric acid price quoted in **CPI Management Service,** December 1, 1980	
Sulphuric acid, fob plants, East, 66° Be, tanks, per tonne	76.40
United States prices in U.S. currency, quoted in **Engineering and Mining Journal,** December 1980	
	($US)
Sulphur elemental	
U.S. producers, term contracts fob vessel at Gulf ports, Louisiana and Texas, per long ton	
Bright	110.-118.50
Dark	109.-117.50
Export prices, ex terminal Holland, per long ton	
Bright	135.00
Dark	134.00
Mexican export, fob vessel, per long ton	
Bright	102.00
Dark	101.00

fob Free on board.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
92503-1	Sulphur of all kinds, other than sublimed sulphur, precipitated sulphur and colloidal sulphur	free	free	free	free
92802-1	Sulphur, sublimed or precipitated; colloidal sulphur	free	free	free	free

TARIFFS (cont'd.)

CANADA (cont'd.)

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
92807-1	Sulphur dioxide	free	free	free	free
92808-1	Sulphuric acid, oleum	10%	13.1%	25%	8.5%
92813-4	Sulphur trioxide	free	free	free	free

MFN Reductions under GATT (effective January 1 of year given)

	1980	1981	1982	1983	1984	1985	1986	1987
				(%)				
92808-1	13.1	11.3	9.4	7.5	5.6	3.8	1.9	free

UNITED STATES

Item No.		
418.90	Pyrites	free
415.45	Sulphur, elemental	free
416.35	Sulphuric acid	free

		1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
422.94	Sulphur dioxide	5.8	5.6	5.3	5.1	4.9	4.7	4.4	4.2

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada. Tariff Schedules of the United States annotated 1980, USITC Publication 1011. U.S. Federal Register Vol. 44, No. 241.

Talc, Soapstone and Pyrophyllite

B.W. BOYD

Talc is a hydrous magnesium silicate, $H_2Mg_3(SiO_3)_4$, formed by the alteration of rocks rich in magnesia (most commonly ultrabasic igneous rocks and sedimentary dolomite) within which it occurs as veinlets, tabular bodies, or irregular lenses. It is a soft, flaky mineral with a greasy feel or "slip", it is readily ground to a fine white or nearly white powder, has a high fusion point, low thermal and electrical conductivity and is relatively chemically inert. Most of the uses of talc depend on its physical properties.

Talc is produced in various grades which are usually classified by end use; cosmetic, ceramic, pharmaceutical and paint. A special, high-quality block talc, used in making ceramic insulators and other worked shapes, is designated "steatite grade".

Soapstone is an impure talcose rock generally occurring in massive, compact deposits from which blocks can be sawn. Soapstone has been used since early times in many parts of the world for carving ornaments, pipes, cookware, lamps and other utensils. The art of carving this rock has survived among the Inuit people of Canada up to the present era. Present uses include metalworkers' crayons, refractory bricks, and blocks for sculpturing.

Pyrophyllite is a hydrous aluminum silicate, $H_2Al_2(SiO_3)_4$, formed by hydrothermal alteration of acid igneous rocks, predominantly lavas which are andesitic to rhyolitic in composition. It resembles talc in physical properties and for this reason finds uses similar to talc, notably in ceramic bodies and as a filler in paints, rubber and other commodities.

In Canada, talc is produced in two provinces, Quebec and Ontario, while pyrophyllite is produced only in Newfoundland.

The value and volume of talc and soapstone shipments increased by about 50 per cent in 1979 relative to 1978 and then dropped back slightly in 1980. The 87 000 tonnes (t) of talc and pyrophyllite at a value of $3,086,000 indicates an average price of $35.47 per t in 1980 which compares with $38.07 per t in 1979 and $35.30 per t in 1978. When inflation is taken into account, the real value per t remained constant over 1978 and 1979 then fell by 16 per cent in 1980.

PRODUCTION AND DEVELOPMENT IN CANADA

Talc, soapstone. The earliest recorded production in Canada was in 1871-72 when 270 t of cut soapstone, valued at $1,800 was shipped from a deposit in L 24, R 6 in Bolton Township, southern Quebec, by Slack and Whitney. In 1896 a deposit in Huntingdon Township, in the Madoc district of Ontario, was opened and over the next few years numerous deposits were discovered in this area and mined intermittently.

Several deposits in southern British Columbia and one in southwestern Alberta were discovered prior to 1920 and some were worked on a small scale. At present, talc is mined by four companies - two in Quebec and two in Ontario.

Bakertalc Inc. produces talc and soapstone from an underground mine at South Bolton, Quebec, 95 kilometres (km) southeast of Montreal. The talc occurs as dykes and

TABLE 1. TALC, SOAPSTONE AND PYROPHYLLITE PRODUCTION, TRADE 1979 AND 1980 AND CONSUMPTION 1978 AND 1979

	1978		1979		1980P	
	(tonnes)	($)	(tonnes)	($)	(tonnes)	($)
Production (shipments)						
Talc and soapstone						
Quebec[1]	..	1,072,476	..	1,499,574	..	1,306,000
Ontario[2]	..	440,324	..	914,257	..	1,025,000
Total	..	1,512,800	..	2,413,831	..	2,331,000
Pyrophyllite						
Newfoundland	..	663,916	..	1,024,877	..	775,000
Total production	61 661	2,176,716	90 330	3,438,708	87 000	3,086,000
Imports						
Talc or Soapstone						
United States	33 099	3,424,000	49 951	4,981,000	50 298	5,881,000
United Kingdom	25	3,000	-	-	63	21,000
Italy	191	30,000	220	27,000	125	18,000
Japan	34	4,000	34	7,000	41	13,000
France	1	-	114	15,000	-	-
Hong Kong	-	-	3	-	-	-
Total	33 350	3,461,000	50 322	5,030,000	50 527	5,933,000

	1978	1979e
	(tonnes)	
Consumption[3] (ground talc available data)		
Paints and varnish	8 639	10 143
Gypsum products	7 528	7 680
Pulp and paper products	7 479	7 311
Roofing products	6 975	7 442
Ceramic products	5 338	5 864
Toilet preparations	2 395	701
Chemicals	1 921	1 027
Rubber products	1 480	2 600
Other products[4]	1 364	4 172
Total	43 119	46 940

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Ground talc, soapstone, blocks and crayons. [2] Ground talc. [3] Breakdown by Mineral Policy Sector, Department of Energy, Mines and Resources, Ottawa. [4] Adhesives, floor covering, insecticides and other miscellaneous uses.

P Preliminary; .. Not available; e Estimated; - Nil.

sills in Cambrian and Lower Ordovician schists. Ore from the mine is trucked 16 km south to the company's mill facilities at Highwater.

Shaft sinking to the 182-metre (m) level was completed in 1976 and development and production at this level commenced in 1977. Mining is by open stoping, and access and ore hoisting are by way of a 45° inclined shaft.

A modified flotation process is used to produce a high-quality talc for use principally in the paper industry. A small quantity has been used as a filler in plastics and paints. Production of this high-quality material is around 5 000 tpy and a somewhat larger tonnage of lower-grade talc, produced in a dry-milling process, is shipped for a variety of uses. The company also sells soapstone blocks for sculpture to an art supplies dealer.

Bakertalc began exploration programs in Nova Scotia and Alberta but results have not yet been reported.

B.S.Q. Talc Inc. quarries talc and soapstone from two deposits near Broughton Station in the Eastern Townships of Quebec, where the same geological conditions as in the South Bolton area are evident. Several low-priced grades of ground talc are produced, and soapstone is sawn to produce metalworkers' crayons and various sizes of blocks for sculpturing, and plates for etching. Much of the Inuit artists' soapstone requirements are supplied by this company and a certain volume is marketed elsewhere through an art supplies company.

Canada Talc Industries Limited produces talc from underground workings at Madoc, Ontario. The deposits at Madoc are extensive and were formed by the alteration of dolomitic marble. Tremolite and dolomite impurities in the deposit limit the use of some ground products. A high-quality product, suitable as a filler material in paint and plastics and for use in pharmaceuticals, cosmetics and lens polishing, is produced. The company also produces dolomite terrazzo chips from the mine.

The talc ore is mined from drawpoints at 9-m intervals along drifts flanking the ore zone. The mill circuit is comprised of a jaw crusher, Raymond mills and cyclones. The deposit is being developed below the 167-m level.

Johns-Manville Canada Inc. brought its Penhorwood township deposit into production in July 1976 but closed both this operation and one in California in December of the same year, having apparently decided to get out of the talc business. About 10 000 t were produced. The deposit was purchased by the Steetley Minerals Group which, under the subsidiary Steetley Talc Limited, reopened the operation in January 1979. Products for the paper, paint and plastics industries are marketed in North America and overseas.

Numerous deposits of talc and soapstone occur in the producing areas and in other parts of Canada. A soapstone deposit on Pipestone Lake in Saskatchewan was worked by Indians for the manufacture of pipes and various utensils. Reserves are reported to be considerable. High quality "blue" talc was investigated in the Banff area of Alberta and British Columbia during the 1930s. In the Northwest Territories, a few occurrences of soapstone are known from which Eskimos obtained material for carving. Showings of minor importance occur at several localities in Nova Scotia and Newfoundland.

Pyrophyllite. Newfoundland Minerals Limited, a subsidiary of American Olean Tile Company, Inc., produces pyrophyllite from an open-pit mine near Manuels, 19 km southwest of St. John's, Newfoundland. Ore is crushed, sized and hand-cobbed at the mine site prior to being trucked a short distance to tidewater. Continuous chemical analyses and physical tests are run on all material delivered from the mine to the loading dock. Blended ore is shipped in bulk to the parent company's operation at Lansdale, Pennsylvania, where it is used in the manufacture of ceramic tile. Annual production varies between 20 000 and 35 000 t. The pyrophyllite deposit at Manuels appears to be a hydrothermal alteration of sheared rhyolite. Altered zones are associated for the most part with extensive fracturing near intrusive granite contacts. Reserves are extensive.

Other known pyrophyllite deposits in Canada include an extensive area of impure pyrophyllite near Stroud's Pond in the southern part of Burin Peninsula, Newfoundland; a deposit near Ashcroft, British Columbia and three deposits on Vancouver Island, British Columbia in the Kyuquot

TABLE 2. CANADA, TALC PRODUCTION AND TRADE, 1970, 1975-80

	Production[1]	Imports
	(tonnes)	
1970	65 367	29 999
1975	66 029	30 428
1976	68 834	46 397
1977	72 400	33 769
1978	61 661	33 350
1979	90 330	50 322
1980P	87 000	50 527

Sources: Statistics Canada; Energy, Mines and Resources Canada.

[1] Producers' shipments.

P Preliminary.

Sound area 320 km northwest of Victoria. The Vancouver Island deposits were worked on a limited scale in the early part of this century.

TRADE AND MARKETS

All Canadian production of pyrophyllite is exported. Total exports of Canadian pyrophyllite, talc and soapstone are roughly equivalent to our total imports of talc. Except for minor shipments of these materials to South Africa, exports go to the United States, where demand for good-quality filler for automobile plastics has grown rapidly over the last few years. Imported talc, most of it from the United States, is high-quality, high-value material suitable for use in the paint, ceramics, paper and cosmetic industries. It is anticipated that imported high-quality talc will be displaced to some extent in other industries by domestic product as capacity for producing these grades increases.

Imports of talc increased in 1979 to 50 322 t from 33 350 t in 1978. The 1980 import figure of 50 527 t was nearly the same as in 1979 but value increased by 18 per cent. The average value per t on imports dropped slightly from $103.78 per t in 1978 to $99.95 in 1979, and then rose to $117.42 per t in 1980. Domestic production had average values of $35.30 to $38.07 over those years.

USES

Talc is used mostly in a fine-ground state; soapstone in massive or block form. There are many industrial applications for ground talc, but major consumption is limited to less than a dozen countries.

Talc is used as a filler material in the manufacture of high-quality paper where it aids in the dehydration of the pulp, improves sizing characteristics, reduces the tendency of papers to yellow and assures a well-bonded surface to promote ease of printing. For use in the paper industry, talc must be free of chemically active compounds such as carbonates, iron minerals and manganese, have a high reflectance, possess high retention characteristics in the pulp, and be free of abrasive impurities. Micronized material provides a high-gloss finish on coated papers.

The ceramic industry utilizes very finely ground talc to increase the translucence and toughness of the finished product and aid in promoting crack-free glazing. For use in ceramics, talc must be low in iron, manganese and other impurities which would discolour the fired product.

TABLE 3. WORLD PRODUCTION OF TALC, SOAPSTONE, AND PYROPHYLLITE, 1977-80

	1977	1978P	1979^e	1980^e
	(tonnes)			
Japan	1 358 954	1 271 873	1 428 816	1 361 000
United States	1 093 008	1 201 735	1 317 897	1 179 000
Republic of Korea	605 229	665 083	680 389	..
U.S.S.R.^{e}	453 592	471 736	480 808	..
India	281 618	308 249	317 515	..
France	286 499	303 491	303 907	363 000
Brazil	253 882	240 495	254 919	..
Finland	156 584	195 159	199 581	181 000
Italy	162 437	175 157	174 996	181 000
People's Republic of China^e	149 685	149 685	149 685	..
Australia	112 290	151 613	140 614	..
North Korea^e	127 000	127 000	127 000	..
Austria	103 751	106 848	108 862	..
Norway	98 087	109 769	109 769	..
Canada	72 400	61 661	90 330	87 000
Other countries	309 800	334 588	329 017	2 817 000
Total	5 624 816	5 874 142	6 214 105	6 169 000

Sources: U.S. Bureau of Mines Preprints 1978-79; and U.S. Bureau of Mines, Mineral Commodity Summaries, January 1981; Energy, Mines and Resources Canada.
P Preliminary; ^{e} Estimated; .. Not available.

High-quality talc is used as an extender pigment in paints. Specifications for a talc pigment relate to its chemical composition, colour, particle size, oil absorption and consistency of and dispersion in a talc-vehicle. A low carbonate content, a nearly white colour, a fine particle size with controlled particle size distribution and a specific oil absorption are important. However, because of the variety of paints, precise specifications for talc pigments are generally based on agreement between consumer and supplier. Paint characteristics influenced by the use of talc as extender are gloss, adhesion, flow, hardness and hiding power.

Talc is well known for its use in pharmaceutical preparations and cosmetics. It is the major ingredient in face, baby and body powders. Finely ground, high-purity material is used as a filler in tablets and as an additive in medical pastes, creams and soaps. Material used for these purposes should be free of deleterious chemical compounds, abrasive impurities and fibrous minerals such as tremolite and asbestos, which could be injurious to health when inhaled or ingested.

Lower-grade talc is used as a dusting agent for asphalt roofing and gypsum board, as a filler in drywall sealing compounds, as a filler material in floor tiles, in asphalt pipeline enamels, in auto-body patching compounds, as a carrier for insecticides and as a filler or dusting compound in the manufacture of rubber products.

Other applications for talc include use in cleaning compounds, polishes, electric cable coating, plastic products, foundry facings, adhesives, linoleum, textiles and in the food industry.

Particle-size specifications for most uses require the talc to be minus 325 mesh. The paint industry demands from 99.8 to 100 per cent minus 325 mesh. For rubber, ceramics, insecticides and pipeline enamels, 95 per cent minus 325 mesh is usual. In the wall tile industry, 90 per cent minus 325 mesh is generally required. For roofing grades the specification is about minus 80 mesh, with a maximum of 30 to 40 per cent minus 200 mesh.

Soapstone has now only very limited use as a refractory brick or block, but, because of its softness and resistance to heat, it is still used by metalworkers as marking crayons. The ease with which it can be carved makes it an excellent artistic medium.

Pyrophyllite can be ground and used in much the same way as talc, but at present the use of the Canadian material is confined to ceramic tile. The pyrophyllite imparts a very low coefficient of thermal expansion to ceramic tile which makes it a preferred raw material. It must be minus 325 mesh and contain a minimum of quartz and sericite, which are common impurities.

WORLD REVIEW

Deposits of talc are widely distributed throughout the world, but have been developed commercially only in the more industrialized countries. Because talc is of relatively low unit value, only a very minor part of world production is traded internationally. The majority of international trade takes place within Europe; in the Far East between Japan, the People's Republic of China and Korea; and in North America between Canada and the United States. However, talc of exceptional purity is valuable enough to withstand the cost of transportation over much greater distances. For example, high-grade French, Italian, Indian and Chinese talcs are shipped throughout the world.

PRICES OF TALC IN U.S. CURRENCY

		($ per short ton)
Canadian:	ground, bags carlot, f.o.b. works	20.00-35.00
Vermont:	domestic, ordinary, off-colour, ground, bags, carlot, f.o.b. works	22.25
California:	domestic, ordinary, ground, bags, carlot, f.o.b. works	34.00-39.50
New York:	domestic, ground, bags, carlot, f.o.b. works	35.50

Source: Chemical Marketing Reporter, December 29, 1980.
fob free on board.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
71100-3	Talc or soapstone	10	14.3	25	9.5
29646-1	Talc for use in manufacture of pottery or ceramic tile (expires Feb. 28, 1980)	free	free	25	free
29647-1	Micronized talc, not exceeding 20 microns	free	4.9	25	free
29655-1	Pyrophyllite	free	free	25	free

MFN Reductions under GATT (effective January 1 of year given)

	1980	1981	1982	1983	1984	1985	1986	1987
				(%)				
71100-3	14.3	13.6	12.8	12.1	11.4	10.7	9.9	9.2
29647-1	4.9	4.8	4.6	4.5	4.4	4.3	4.1	4.0

UNITED STATES

Item No.									
523.31	Crude and not ground	0.02¢ per lb.							
		1980	1981	1982	1983	1984	1985	1986	1987
523.33	Ground, washed, powdered, or pulverized	5.6%	5.1%	4.7%	4.2%	3.8%	3.3%	2.9%	2.4%
523.35	Cut or sawed, or in blanks, crayons, cubes, disks or other forms, per lb.	.1¢	.1¢	.1¢	.1¢	free	free	free	free
523.37	All other, not provided for	9%	6%	4.8%	4.8%	4.8%	4.8%	4.8%	4.8%

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated 1980, USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241.

Tin

G.E. WITTUR

Canada is a relatively small producer of tin but ranks about ninth as a consumer among non-communist countries. Production of tin in concentrates and lead-tin alloy in 1980 was 264 tonnes (t) valued at $5.9 million, compared with 337 t in 1979 valued at $5.6 million. Tin concentrates are exported for smelting as mine production is too small to justify a domestic smelter.

Canadian industrial requirements of tin are met mainly by imports, which totalled 4 527 t in 1980 valued at $89 million, compared with 4 689 t in 1979 valued at $81.1 million. Southeast Asia is Canada's main source of tin but most tin is purchased by Canadian consumers from metal merchants and transshipped through New York, which generally is more economic than importing directly from producing countries. As a result, official Canadian statistics (Table 1) show the United States as the major import source. Some tin is also imported through other intermediate countries as well as directly from primary tin mining or smelting countries.

Canada also imports relatively small amounts of tinplate and other tin products from the United States and elsewhere. Most tinplate scrap and other tin metal scrap is exported, mainly to the United States, as facilities for the recovery of secondary tin are limited in Canada. Tin-bearing solders are recovered from automobile radiators and scrap plumbing at a few plants, one of which is Federated Genco Limited in Scarborough, Ontario. Also, tin is recovered as potassium stannate through the detinning of industrial and municipal scrap by Metal Recovery Industries Ltd. of Hamilton, which sells the product to the electroplating industry. However, statistics on recycled tin are not available.

Two Canadian mines recover small amounts of tin concentrates as byproducts of base-metal mining and milling. These are Cominco Ltd. at Kimberley, British Columbia, and Texasgulf Canada Ltd. at Timmins, Ontario. Cominco also recovers about 600 tpy of lead-tin alloy (8 per cent tin) from the treatment of lead bullion dross in the indium circuit at its Trail smelter, and produces small quantities of special research grade tin (99.999 per cent) and "Tadanac" high-purity tin (99.9999 per cent) from purchased commercial-grade metal. Tin is present in small quantities in several other sulphide deposits in Canada but its recovery is apparently not economic.

Tin mineralization is known in several areas in Canada, in both lode and alluvial occurrences, but the small size of known occurrences, their low grades and other factors did not encourage much exploration interest until tin prices rose significantly during the 1970s.

The most promising reported tin prospect is a large, low-grade deposit discovered in 1979 by Shell Canada Resources Limited near East Kemptville, Nova Scotia, approximately 40 km northeast of Yarmouth. Exploration continued in 1980, with reserves as of year end reported to total 38 million t averaging just under 0.2 per cent tin. The deposit is

TABLE 1. CANADA, TIN PRODUCTION, IMPORTS AND CONSUMPTION, 1979 AND 1980

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Production				
Tin content of tin concentrates and lead-tin alloys	337	5,564,651	264	5,898,000
Imports				
Blocks, pigs, bars				
United States	3 091	56,277,000	3 153	61,848,000
Bolivia	410	4,128,000	617	12,165,000
Brazil	69	1,181,000	279	5,552,000
Netherlands	85	1,553,000	175	3,425,000
Singapore	255	4,465,000	165	3,234,000
United Kingdom	526	9,311,000	43	907,000
Other countries	253	4,187,000	95	1,891,000
Total	4 689	81,102,000	4 527	89,022,000
Tinplate				
United States	1 292	1,039,000	1 690	1,435,000
United Kingdom	197	343,000	243	501,000
Netherlands	-	-	1	2,000
Hong Kong	5	4,000	-	-
Total	1 494	1,386,000	1 934	1,938,000
Tin, fabricated materials, nes				
United States	311	1,453,000	437	1,205,000
United Kingdom	40	137,000	49	176,000
West Germany	4	8,000	2	7,000
Other countries	79	6,000	5	11,000
Total	434	1,604,000	493	1,399,000
Exports				
Tin in concentrates, recycled metal and scrap				
United Kingdom	2	14,000	165	1,784,000
Mexico	25	315,000	156	1,423,000
United States	637	4,637,000	548	854,000
Other countries	48	44,000	-	-
Total	712	5,010,000	869	4,061,000
Tinplate scrap (total tonnage)				
United States	2 863	237,000	2 522	162,000
Netherlands	-	-	26	31,000
Italy	-	-	879	29,000
Other countries	-	-	72	18,000
Total	2 863	237 000	3 499	240,000
Consumption				
Tinplate and tinning	2 307	..	..	..
Solder	1 955	..	..	..
Babbit	199	..	..	..
Bronze	55	..	..	..
Other uses (including collapsible containers, foil, etc.)	159	..	..	..
Total	4 675	..	4 766e	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.
P Preliminary; - Nil; nes Not elsewhere specified; .. Not available; e Estimated.

flat-lying, with depths limited to about 100 m. An extensive assessment program is scheduled for 1981, including underground exploration, sampling and mill tests to provide information for a mine feasibility study in the latter part of the year.

Billiton Canada Ltd. and Brunswick Tin Mines Limited (89 per cent owned by Sullivan Mining Group Ltd.) are developing a tungsten-molybdenum deposit (the Fire Tower Zone) in New Brunswick for production in 1982. While the tin content is reported to be 0.04 per cent there are apparently no plans for its recovery. The nearby North Zone includes a reported 2.3 million t grading 0.42 per cent tin as well as containing other metals and could be developed at a later date. Billiton's Netherlands-based parent, Billiton B.V., is a subsidiary of the Royal Dutch-Shell group and has major international tin mining and smelting interests in Southeast Asia, mines in the United Kingdom, and a smelter in Holland.

Consumption of tin reported in Canada peaked in 1977 at nearly 5 300 t but has since declined. Estimated consumption in 1980 was 4 766 t (Table 2). Tinplate is the largest tin user, accounting for about half the total. It is estimated that in 1980, 2 463 t of tin were used in producing about 475 000 t of tinplate at the two producers, Dofasco Inc. and Stelco Inc., both at Hamilton, Ontario. Each company operates three electrolytic tinplate lines, and each has one tinplate line that is also capable of applying other coatings such as chromium. Stelco began shipping tin-free coated sheet made on its convertible line in 1980.

The manufacture of solders, which are various alloys of tin and lead, is the second-largest use of tin and absorbs about 2 000 tpy of tin. Canadian solder producers include The Canada Metal Company, Limited (50 per cent owned by Cominco Ltd.), Federated Genco Limited, Cramco Alloy Sales Limited, Kester Solder Company of Canada Limited, Toronto Refiners and Smelters Limited, and Metals & Alloys Company Limited.

THE INTERNATIONAL TIN AGREEMENT

Tin is the only metal for which there is an international agreement between producers and consumers that contains economic provisions for market stabilization. The Fifth International Tin Agreement (ITA) came into force on July 1, 1976 and is effective until June 30, 1982, having been extended by one year early in 1981 to permit negotiation of a Sixth Agreement. Provisions for a buffer stock and export controls are intended to limit price fluctuations within an agreed-upon price range. However, tin market prices have remained above the upper price limit for essentially the entire period of the Fifth Agreement, despite five increases in the price range between late-1976 and April 1980. The buffer stock was exhausted in January 1977 and cannot be replenished through normal market purchases until the tin price falls into at least the middle range of the price limits, and, in practice, until it falls into the lower range. However, the United States has offered a contribution of 1 500 t of tin metal to the buffer stock from surplus strategic stocks and it is anticipated that this will be transferred to the buffer stock manager in 1981.

TABLE 2. CANADA, TIN PRODUCTION, EXPORTS, IMPORTS AND CONSUMPTION, 1970, 1975-80

	Production[1]	Exports[2]	Imports[3]	Consumption[4]
		(tonnes)		
1970	120	268	5 111	4 565
1975	319	1 052	4 487	4 315
1976	274	777	4 224	4 849
1977	328	876	5 028	5 286
1978	360	943	4 809	4 922
1979	337	712	4 689	4 675
1980[p]	264	869	4 527	4 766[e]

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Tin content of tin concentrates shipped plus tin content of lead-tin alloys produced. [2] Tin in concentrates, recycled metal and scrap (excluding tinplate scrap). [3] Tin metal. [4] Current coverage exceeds 90 per cent, whereas until 1972, coverage was in the order of 80-85 per cent.
[p] Preliminary; [e] Estimated.

The Fifth Agreement was scheduled to expire on June 30, 1981 and negotiations on a Sixth five-year agreement began in April 1980. The first negotiating conference, and a second held in November 1980, were unsuccessful in producing an agreed-upon text and consequently the Fifth Agreement was extended by one year early in 1981. Further negotiations are expected in 1981 on unresolved issues, the major ones relating to the maximum size and financing of the buffer stock and conditions under which producing countries may implement export controls when prices fall into or below the lower price range. It is expected that under the Sixth Agreement, the buffer stock will be financed jointly by producers and consumers. Until the Fourth Agreement it was financed entirely by producers, but the Fifth Agreement provided for voluntary contributions from consumers. Canada agreed to contribute up to about $4.5 million as its share of the buffer stock financing during the Fifth Agreement. Some consumers, especially the United States, favour a considerably larger maximum buffer stock under the Sixth Agreement, on the grounds that in the longer-term, consumers would be better protected from tin prices exceeding the ITA price range, with less need for reliance on export controls during periods of excess supply.

WORLD DEVELOPMENTS

Non-communist world production of tin in concentrate totalled 199 400 t in 1980, while smelter production was 200 000 t, both slightly lower than 1979 levels (Tables 3 and 4). Recovery of tin and tin-bearing alloys from secondary sources is not well reported but is significant in industrial countries. In the United States, for example, reported secondary tin recovery has ranged from 16 000 t to 21 000 t annually in recent years, mostly as a constituent of tin-bearing alloys. Reported primary tin consumption was 175 700 t in 1980, down from 183 100 t in 1979 (Table 5). The large reduction in U.K. consumption was the result of a prolonged steel industry strike, while that in the U.S. was attributed to the economic recession, particularly in the automotive industry which is a large user of solders. Major producers/consumers excluded from these figures are the U.S.S.R. and the People's Republic of China; the United States Bureau of Mines estimates their tin production in 1980 to have been in the order of 34 000 t and 22 000 t, respectively, although some other authorities give lower estimates. Although China exports some tin, the communist bloc as a whole (mainly the U.S.S.R.) is a net importer of some 15 000 tpy of tin and, taking this trade into account, there was a statistical surplus in world production over consumption of 10 700 t in 1980, on a metal-to-metal basis, compared with a surplus of 6 000 t in 1979.

TABLE 3. ESTIMATED WORLD[1] PRODUCTION OF TIN-IN-CONCENTRATES, 1970, 1979 AND 1980

	1970	1979	1980P
		(tonnes)	
Malaysia	73 794	62 995	61 404
Thailand	21 779	33 962	33 685
Indonesia	19 092	29 440	32 527
Bolivia	30 100	27 781	27 271
Australia	8 828	12 571	10 837
Brazil	3 610	6 645	6 756
Zaire	6 458	3 300	3 159
United Kingdom	1 722	2 374	3 027
Nigeria	7 959	2 750	2 527
South Africa	1 986	2 693	2 434
Total, including countries not listed	184 900	200 700	199 400

Source: International Tin Council, Statistical Bulletin.

[1] Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary. The People's Republic of China and U.S.S.R. are large tin producers.
P Preliminary.

The United States resumed offerings of tin from its General Services Administration stockpile in 1980, the first since 1978, after President Carter signed the Strategic and Critical Materials Act of 1979. This authorized the disposal of 35 000 t of tin over three years, of which up to 5 000 t is to be made available as a U.S. contribution to the International Tin Council buffer stock. Offerings of 500 t every two weeks for U.S. consumption began on July 1 but the near-consistent rejection of bids by U.S. authorities resulted in no sales except for 5 t on July 29. Therefore, the sale procedure was changed effective December 1 to daily offerings of "off the shelf" tin, but by year-end, 1980 sales totalled only 25 t. Primary tin producing countries nevertheless registered considerable opposition to the U.S. tin sales in view of possible adverse impacts on tin prices despite assurances that such sales would be undertaken so as not to undercut the market. The United States also initiated arrangements to transfer 1 500 t of tin, out of the 5 000 t total authorized, to the International Tin Council buffer stock. The goal for the U.S. strategic stockpile was raised from 33 021 t to 42 674 t in 1980, whereas the stockpile actually totalled 203 690 t at year-end.

TABLE 4. ESTIMATED WORLD[1] PRODUCTION OF PRIMARY TIN METAL, 1970, 1979 AND 1980

	1970	1979	1980^{P}
		(tonnes)	
Malaysia	91 495	73 068	71 318
Thailand	22 040	33 058	34 689
Indonesia	5 190	27 790	30 465
Bolivia	300	15 696	17 648
Brazil	3 100	10 133	8 792
United Kingdom	22 035	8 025	5 829
Australia	5 211	5 423	4 819
Singapore	..	4 000^{e}	4 400
Spain	3 908	4 412^{e}	4 106
United States	4 540	4 656	3 900
Belgium	4 257	2 165	2 822
Nigeria	8 069	2 858	2 684
West Germany	1 195	2 488	638
Total, including countries not listed	183 600	201 400	200 000

Source: International Tin Council, Statistical Bulletin.

[1] Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary.
P Preliminary; ^{e} Estimated; .. not available.

Southeast Asia is the world's leading tin mining area, with Malaysia, Thailand and Indonesia ranking first to third, respectively, among world producers. Together they accounted for 64 per cent of non-communist world production in 1980. Malaysia's production has fallen significantly during the past decade, owing to declining grades, rising costs and high taxes and royalties, but growth in Thailand and Indonesia has offset this. In 1980, Malaysia revised its tin export tax structure whereby export duties are calculated on a cost-plus formula tied to an assumed production cost. The resulting tax reduction was expected to spur new mining investment. In mid-1980, it was announced that a new company, owned 65 per cent by the Selangor State Development Corporation and 35 per cent by Malaysia Mining Corp Bhd., tentatively planned to develop the large Kuala Langat deep alluvial tin deposit at a cost of about $US 100 million phased over a decade. Tin production could eventually reach as much as 6 000 tpy from dredging depths down to about 100 m.

TABLE 5. ESTIMATED WORLD[1] CONSUMPTION OF PRIMARY[2] TIN, 1970, 1979 AND 1980

	1970	1979	1980^{P}
		(tonnes)	
United States	53 807	49 200	46 000
EEC, total[3]	58 246	47 888	45 242
West Germany	14 062	13 655	14 272
United Kingdom	16 951	11 094	6 730
France	10 500	9 660	10 059
Italy	7 200	6 000	5 800
Netherlands	2 139	5 413	5 012
Japan	24 710	31 219	30 879
Brazil	2 139	5 413	5 012
Canada	4 640	4 675	4 766
Total, including countries not listed	184 800	183 100	175 700

Source: International Tin Council, Statistical Bulletin.

[1] Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary. [2] May include some secondary tin in some countries. [3] Includes the nine members in 1980 in all years.
P Preliminary.

Bolivia was long the world's number two tin producer but it was surpassed by both Thailand and Indonesia in 1979. Unlike Southeast Asia where tin occurs mainly in alluvial deposits, most Bolivian tin is mined from underground lode deposits. Declining grades, rising production costs and taxes, labour strikes, and Bolivia's unstable political situation have made it difficult for tin mines to remain profitable. In 1980, the government dropped export duties and combined various national and regional production and profits taxes into a single "profits" tax. The deemed production cost upon which this tax is calculated was raised significantly, thus reducing taxable income and tax payments. A tin industry "regeneration" program, proposed by the Bolivian government in 1980, was not ready for implementation at year-end.

In Australia, Renison Limited in Tasmania, which operates the world's largest lode tin mine, neared completion of an A$18 million expansion in 1980 which will raise daily ore capacity to 2 300 t. It is also investigating the feasibility of a tin fuming plant to treat lower grade concentrates to improve overall tin recovery.

In Brazil, Brascan Limited of Canada purchased a 96 per cent interest in a 6 800 tpy tin smelter at Volta Redonda and tin properties in the State of Rodonia from Patino N.V. of The Netherlands. Purchase price was $US 32.5 million. Brascan also has other tin producing interests in Brazil.

As in Canada, higher tin prices have encouraged exploration in many other areas of the world, especially in Australia and the ancient tin producing areas of Cornwall in the United Kingdom. In Australia, Greenbushes Tin N.L. announced the discovery of a large tin-tantalum deposit near its existing mining operations in Western Australia. Probable reserves of the partially explored deposit were reported to be nearly 10 million t, using a cut-off grade of 0.6 per cent tin equivalent. Development was estimated to cost A$60 million for a 3 000 tpd mining-milling operation. Another recently discovered tin property in Australia has some features similar to Shell's property in Nova Scotia: a large tonnage of near-surface mineralization averaging 0.17 per cent tin, as well as 4.4 g/t silver and 0.05 per cent copper, but the stripping ratio would be much higher. Several million dollars have been spent on exploration so far, suggesting a possible $60-80 million, 6 000 tpd operation.

Tin smelting continues to shift from the industrial countries, especially in Europe, to the mining countries. According to the International Tin Council, world smelting capacity is nearly twice actual tin mine production, and few smelters operate near their designed capacities. Nevertheless, new smelter capacity continues to be built in mining countries.

In Bolivia, a new smelter designed to recover tin from low grade concentrates and slags was completed in 1979 but continued to experience operating problems through 1980. It is designed to produce up to 10 000 tpy of tin to complement the existing 20 000 tpy smelter and make Bolivia self-sufficient in smelter capacity.

In Malaysia, the government-controlled Malaysia Mining Corp Bhd. (MMC) has been seeking an interest in one or both of the country's two large, privately-owned smelters, one of which was expanded by 20 per cent in 1980. While MMC announced plans to build its own 20 000 tpy smelter in 1980, it is believed that negotiations were continuing with the private smelters. In Thailand, one company is nearing completion of a 3 600 tpy smelter, the country's second, and a third company plans to build a 6 000 tpy smelter. Also in Thailand, the government-controlled Offshore Mining Organization is said to be negotiating with Billiton for an interest in the latter's large Thailand Smelting & Refining Co. Ltd. (Thaisarco) smelter.

In Indonesia, the state-owned Peltim smelter is being expanded to 38 500 tpy with the installation of a fourth reverberatory furnace. Other smelters were completed or announced in 1980 in the Republic of South Africa, Burma and Australia. Alternatively, operating rates at most European smelters are declining owing to concentrate shortages and, in 1980, it was announced that an 18 000 tpy smelter in Belgium would be closed at year-end.

Tin concentrates are subject to export controls in Australia but the government in 1980 decided to phase these out over a two-year period and to substitute an interim bounty of A$55 per t of tin refined in Australia from domestic concentrates above a production minimum. The bounty is to apply for three years to assist Australia's single custom smelter in competing with foreign smelters. Greenbushes Tin N.L. completed Australia's second tin smelter in 1980, a 2 000 t electric furnace plant to process its own tin and tantalum concentrates. Most concentrates exported from Australia are smelted in Malaysia.

OCCURRENCE AND RECOVERY

About 80 per cent of the world's tin output is derived from alluvial deposits. The principal production methods are bucket-line dredging and gravel pump operations. Suction dredges are also used, but in most cases they are less efficient than the bucket-line method. Other methods are hydraulicking and dulang washing. Tin is recovered as cassiterite (SnO_2) and at times is associated with other metals such as wolframite (tungsten), tantalum and other heavy metals.

Economic grades of placer deposits generally range from 0.15 to 0.40 kg of tin per cubic metre of sand, or from 0.008 to

0.02 per cent tin. Leaders in placer tin production are Malaysia, Thailand and Indonesia. The industry is labour-intensive, employing over 100,000 people in these three countries.

Lode mining, though less common than alluvial mining, still accounts for most of the tin output of Bolivia, Australia, Britain and South Africa. Countries of the communist and socialist blocs, notably The People's Republic of China and the U.S.S.R., are also important producers of tin from lode mines. Viable lode deposits normally range in grade from 0.4 per cent or less in open-pit mines to 0.9-1.0 per cent or more in underground mines. Silver, tungsten, bismuth and lead are common byproducts of lode mines. Cassiterite is the predominant tin-bearing mineral of lode deposits but stannite, a copper-tin-iron-bearing sulphide, is of some importance.

Average grades in both placer and lode mining tended to decline during the 1970s and this trend is expected to continue. Productivity improvements have offset part but not always all of this decline and real tin production costs have risen, exacerbated by high royalty and tax rates levied by some producing countries.

Concentrating processes for alluvial and most lode tin are based on relatively simple gravity separation methods that produce concentrates ranging from 50 to 76 per cent tin. Magnetic and electrostatic separation are also used. However, mill recoveries of tin from lode deposits often are quite low by base-metal standards and some companies have installed flotation cells in their beneficiating plants to complement gravity separation and improve the recovery of tin and other metals. Fuming processes, which can recover tin as tin oxide from slags, residues, low-grade concentrates and even directly from ores, are being used increasingly to improve overall tin recovery. The impure oxide is converted to metal in conventional smelters.

USES

The major use of tin is in tinplate and tinning, which account for over 40 per cent of the world's consumption. The manufacture of solders is the second-largest use of tin, accounting for just over one-quarter of the world's total. Tin is also used in the manufacture of babbit, bronze and brass alloy, pewter, and in the chemical industry.

The Tin Review for 1978 gives a more-detailed description of the many uses of tin.

PRICES AND TARIFFS

Table 6 lists monthly tin prices in 1980. Tin prices rose sharply after 1973, when the average N.Y. composite price was $US 2.27 a

TABLE 6. MONTHLY AVERAGE TIN PRICES, 1980

	Cdn. ¢/lb	N.Y. Composite US ¢/lb	N.Y. Dealer US ¢/lb	Penang Market Malaysia US Equiv. ¢/lb
January	987.45	837.36	780.64	738.78
February	1 015.85	868.73	805.58	764.41
March	1 064.73	898.60	820.90	791.40
April	1 052.29	876.66	794.32	764.20
May	1 033.10	868.50	785.24	763.06
June	994.91	853.46	776.67	755.98
July	981.06	843.16	773.55	750.63
August	985.04	839.22	775.81	750.75
September	1 023.36	868.98	803.05	776.36
October	994.15	840.00	770.46	741.51
November	957.12	798.00	721.18	696.95
December	920.65	759.56	673.86	652.73
Average	1 000.81	846.01	773.44	745.56

Sources: Canadian prices as quoted in **Northern Miner**; N.Y. Composite, N.Y. Dealer, Penang Market and Malaysia prices as quoted in **Metals Week.**

pound, and reached an average of $7.09 in November 1978. In 1979, prices were comparatively stable during the first three quarters but then rose significantly during the last quarter and into the early months of 1980, peaking at an average of $8.99 in March. Thereafter, prices trended downward for the rest of the year under the influence of depressed demand. Tin offerings by the United States from its stockpile might have contributed to price weakness but actual sales were not significant.

Tin tariffs of Canada and the United States are given in the Tariff table. Neither has tariffs on tin ores, concentrates or unwrought tin, and both agreed during the Tokyo Round of GATT to reduce MFN rates on tin-containing manufactures over an eight-year period beginning in 1980. Tariffs levied by the European Community and Japan are broadly similar to those of the United States, being free for ores, concentrates and unwrought metal from all sources and mostly between 4 and 8 per cent on tin products (MFN) or free from developing countries.

OUTLOOK

After peaking in 1972, world tin consumption fell precipitously in 1973-75 due to the widespread economic recession, and then recovered only slowly during the second half of the decade. Tin consumption is closely related to overall economic trends, but there is some evidence of substitution away from tin, especially for containers, owing in part to escalation of tin prices during the past few years. Price trends have encouraged greater interest in tin exploration and development worldwide but this has been slow to impact on actual tin supply.

Should tin price escalation continue during the 1980s, the possibility becomes greater of an increasing excess supply, but the most likely scenario for the 1980s, assuming the successful implementation of a Sixth International Tin Agreement, is for a continuing, approximate balance between supply and demand and possibly a general levelling in real tin prices as differential cost pressures abate. Under such a scenario, world tin consumption is expected to grow only slowly at best during the decade, with growth in developing countries largely offset by stagnated or even declining use in major industrial countries.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
32900-1	Tin in ores and concentrates	free	free	free	free
33507-1	Tin oxides	free	14.7%	25%	free
33910-1	Collapsible tubes of tin or lead coated with tin	10%	16.6%	30%	10%
34200-1	Phosphor tin	5%	7.3%	10%	4.5%
34300-1	Tin in blocks, pigs, bars or granular form	free	free	free	free
34400-1	Tin strip waste and tin foil	free	free	free	free
38203-1	Sheet or strip, iron or steel, corrugated or not, coated with tin	10%	12.5%	25%	7.5%
43220-1	Manufactures of tin plate	15%	16.6%	30%	11%

MFN Reductions under GATT (effective January 1 of year given)

	1980	1981	1982	1983	1984	1985	1986	1987
				(%)				
33507-1	14.7	14.4	14.1	13.8	13.4	13.1	12.8	12.5
33910-1	16.6	15.7	14.8	13.9	12.9	12.0	11.1	10.2
34200-1	7.3	7.0	6.8	6.5	6.3	6.0	5.8	5.5

TARIFFS (cont'd)

	1980	1981	1982	1983	1984	1985	1986	1987
					(%)			
38203-1	12.5	12.5	11.8	11.0	10.3	9.5	8.8	8.0
43220-1	16.6	15.7	14.8	13.9	12.9	12.0	11.1	10.2

UNITED STATES (MFN)

Item No.		
601.48	Tin ore and black oxide of tin	free
622.02	Unwrought tin other than alloys of tin	free
622.04	Unwrought tin, alloys of tin	free
622.10	Tin waste and scrap	free

		1980	1981	1982	1983	1984	1985	1986	1987
						(%)			
622.15	Tin plates, sheets and strips, not clad	5.6	5.1	4.7	4.2	3.8	3.3	2.9	2.4
622.17	Tin plates, sheets and strips, clad	11.1	10.2	9.3	8.4	7.5	6.6	5.7	4.8
622.20	Tin wire, not coated or plated with metal	3.0	2.4	2.4	2.4	2.4	2.4	2.4	2.4
622.22	Tin wire, coated or plated with metal	5.8	5.6	5.3	5.1	4.9	4.7	4.4	4.2
622.25	Tin bars, rods, angles shapes and sections	5.8	5.6	5.3	5.1	4.9	4.7	4.4	4.2
622.40	Tin pipes, tubes and blanks	5.6	5.1	4.7	4.2	3.8	3.3	2.9	2.4
644.15	Tin foil	16.2	14.9	13.6	12.3	10.9	9.6	8.3	7.0

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated 1980, USITC Publication 1011; U.S. Federal Register, Vol. 44, No. 241.

Titanium and Titanium Dioxide

D.G. LAW-WEST

CANADA

QIT-Fer et Titane Inc. (QIT), owned two-thirds by Kennecott Corporation and one-third by New Jersey Zinc Company, is the only company that mines and processes titanium ore in Canada. Ilmenite is the titanium-bearing ore mineral. The ore is mined by open-pit methods in the Lac Tio-Lac Allard region of eastern Quebec and is crushed at the site to minus 7.5 centimetres (cm). After a short haul by rail to the port of Havre St-Pierre, it is loaded aboard ore carriers for transportation along the St. Lawrence River to the company's upgrading plant and smelter at Sorel, Quebec, which is located about 90 kilometres (km) northeast of Montreal.

Processing at the Sorel plant involves upgrading the ore from an average content of 86 per cent ilmenite to 93 per cent using heavy media separation, spiral and cyclone concentrating techniques. The upgraded ore is calcined in a rotary kiln to reduce the sulphur content, cooled, mixed with powdered anthracite and smelted in electric arc furnaces. "Sorelslag", a titanium slag containing 70 to 72 per cent titanium dioxide (TiO_2), and "Sorelmetal", a pig iron with a low manganese content, are produced. The titanium slag is used primarily in the production of TiO_2 pigment by the sulphate process and the pig iron is principally used in the manufacture of ductile iron. Pig iron is also used as the iron component in powder metallurgy and as a scrap iron substitute in steelmaking. "Sorelflux", a third product consisting of screened ilmenite ore with a grain size of between 6.4 and 38.0 millimetres (mm), is sold as a metallurgical flux.

During 1980 the production of Sorelslag reached 874 710 tonnes (t) compared with 477 030 t in 1979 when a strike halted production for four months.

About 90 per cent of the titanium slag produced in Canada is exported, mainly to the United Kingdom, western Europe and the United States. The remainder is consumed by two Canadian titanium dioxide pigment producers: NL Chem Canada Inc. at Varennes, Quebec and Tioxide Canada Inc. at Tracy, Quebec. Together these two companies produce about 72 000 tpy of TiO_2 pigment and supply approximately 90 per cent of the 60 000 t of annual Canadian consumption.

WORLD DEVELOPMENTS

Titanium Minerals

Australia maintained its position as the major source of titanium minerals by producing some 290 000 t of rutile and 1 240 000 t of ilmenite during 1980. The Richards Bay Iron & Titanium (Pty.) Ltd. in South Africa increased smelter production by 20 per cent over 1979 to produce 350 000 t of high-grade titanium dioxide (TiO_2) slag and 188 000 t of high purity, low manganese iron in 1980. The slag grades 85 per cent TiO_2 and can be used in either sulphate or chloride process pigment plants.

TABLE 1. CANADA, TITANIUM PRODUCTION AND TRADE, 1979 AND 1980

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Production (shipments)				
Titanium dioxide, slag	..	88,155,899	..	110,599,000
Imports				
Titanium dioxide, pure				
United States	3 779	5,111,000	3 817	5,652,000
United Kingdom	1 219	1,631,000	565	1,094,000
France	1 626	1,707,000	809	960,000
West Germany	2 521	2,685,000	304	466,000
Other countries	670	791,000	640	730,000
Total	9 815	11,925,000	6 135	8,902,000
Titanium dioxide, extended				
United States	189	370,000	111	281,000
United Kingdom	1 146	1,331,000	36	57,000
Switzerland	1	3,000	1	4,000
France	179	168,000	-	-
Total	1 515	1,872,000	148	342,000
Titanium metal				
United States	660	16,372,000	932	26,851,000
United Kingdom	55	1,358,000	53	2,002,000
Belgium-Luxembourg	5	395,000	-	-
Other countries	10	160,000	1	50,000
Total	730	18,285,000	986	28,903,000
Exports[1] to the United States				
Titanium metal, unwrought including waste and scrap	302	1,368,000	257	1,794,000
Titanium metal, wrought	426	3,799,000	441	4,203,000
Titanium dioxide	17 970	17,970,000	9 367	10,445,000

Sources: Energy, Mines and Resources Canada; Statistics Canada.
[1] U.S. Department of Commerce, U.S. General Imports, Report F.T. 135. Canadian export statistics do not provide separate categories.
P Preliminary; - Nil; .. Not available.

The Sierra Rutile Ltd. a joint venture of Bethlehem Steel Corporation (85 per cent) and Nord Resources Corporation (15 per cent), both U.S. firms, produced approximately 53 000 t of rutile from its deposit in Sierra Leone. However, some metallurgical problems remain to be solved before the design capacity of 100 000 tpy can be attained.

Titanium Metal

There was a significant increase in both planned and actual production capacity of titanium sponge metal during 1980. In the United States, all three integrated titanium producers announced completed and planned increases in sponge capacity. The TIMET Division of Titanium Metals Corporation of America, the largest of the three, increased sponge capacity by 12 per cent from 11 300 t to 12 700 t in 1980. TIMET also announced plans to further increase capacity to 14 500 tpy. RMI Co. completed the first phase of its expansion program by increasing capacity by 25 per cent to 8 600 tpy. The second-phase expansion will increase capacity by an additional 20 per cent. In order to use the increased sponge production, RMI has invested some $US 8 million in a second

TABLE 2. CANADIAN TITANIUM PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975-80

	Production		Imports			Consumption	
	Ilmenite[1]	Titanium Dioxide Slag[2]	Titanium Dioxide Pure	Titanium Dioxide Extended[3]	Total Titanium Dioxide Pigments	Titanium Dioxide Pigments	Ferro-titanium[4]
				(tonnes)			
1970	1 892 290	766 300	2 523	7 415	9 938	40 290	24
1975	1 543 480	749 840	2 467	241	2 708	..	25
1976	1 702 900	814 060	4 965	276	5 241	..	14
1977	1 442 280	692 330	4 478	496	4 974	..	25
1978	1 809 990	850 030[r]	6 595	498	7 093	..	34
1979	1 004 260	477 030	9 815	1 515	11 330	..	23
1980P	1 853 270	874 710	6 135	148	6 283	..	..

Sources: Energy, Mines and Resources Canada; Statistics Canada; Company reports.
[1] Ore treated at Sorel; from company reports. [2] Slag with 70 to 72 per cent TiO_2; from company reports. [3] About 35 per cent TiO_2. [4] Ti contents.
P Preliminary; .. Not available; [r] Revised.

TABLE 3. TITANIUM SLAG AND IRON PRODUCTION, QIT-FER ET TITANE INC., 1970, 1975-80

	Ore Treated	Titanium Slag	Iron
		(tonnes)	
1970	1 892 290	766 300	539 720
1975	1 543 480	749 840	499 890
1976	1 702 900	814 060	551 100
1977	1 442 280	692 330	459 250
1978	1 809 990	850 030[r]	595 000
1979	1 004 260	477 030	339 660
1980P	1 853 270	874 710	622 330

Source: Kennecott Corporation Annual Report.
P Preliminary; [r] Revised.

3 000 t open-die forging system to produce ingot, billet and slab products. Oregon Metallurgical Corp., the third U.S. integrated titanium producer, plans to increase sponge capacity by 50 per cent to 8 160 tpy by mid-1981.

In Japan, there are two titanium sponge producers and both expanded their production capacities in 1980. Toho Titanium Co. Ltd. completed an expansion plan which boosted its capacity by 25 per cent to 9 000 tpy, while Oska Titanium Corp. increased its capacity by 54 per cent to 12 960 tpy. Other projects due for completion in 1981 will raise total Japanese sponge capacity to about 24 000 tpy.

The IMI Titanium unit of Imperial Metals Industries Ltd. (IMI) in the United Kingdom announced plans to double the capacity of its smelting and forging operations at Birmingham, as well as its rolling mills in South Wales, during the next five years. Deeside Titanium Ltd., a recently formed company, will provide IMI with additional feed from a new titanium granule plant scheduled to begin production in 1982 at a rate of 5 000 tpy. The new company is owned 62.5 per cent by Billiton U.K. Ltd., 20.0 per cent by Rolls Royce and 17.5 per cent by IMI.

PROCESSING AND USES

Nearly 90 per cent of all titanium ore produced is used in the production of titanium dioxide pigments. Titanium dioxide is widely used in the pigment industry because of its high index of refraction, which gives pigments their extreme whiteness and opacity. In addition, titanium dioxide pigments are resistant to chemical attack, thermally stable, resistant to ultra-violet degradation and nontoxic. Titanium dioxide can be won from titanium ores by two processes: the sulphate method, which can use ilmenite and ilmenite slag, or the chloride method, which can use natural or synthetic rutile and high-grade ilmenite slag.

TABLE 4. PRODUCTION OF ILMENITE CONCENTRATE BY COUNTRIES, 1978-80

	1978	1979P	1980[e]
		(tonnes)	
Australia	1 259	1 143	1 243
Norway	767	810	816
Canada[1]	850	477	871
United States	535	580	499
U.S.S.R.[e]	408	408	..
Malaysia	187	187	..
India[e]	150	150	154
Finland	132	132	..
Republic of South Africa	91	299	381
Sri Lanka	33	35	..
Other Countries	774	780	780
Total	5 186	5 001	4 744

Sources: U.S. Bureau of Mines, **Minerals Yearbook Preprint, 1978-79**; U.S. Bureau of Mines, Mineral Commodity Summaries, January 1981.

[1] Titanium slag containing 70-71% TiO_2.

P Preliminary; [e] Estimated; .. Not available.

TABLE 5. PRODUCTION OF RUTILE BY COUNTRIES, 1978-80

	1978	1979P	1980[e]
		(tonnes)	
Australia	265 624	277 000	280 000
United States	..	-	..
U.S.S.R.[e]	29 937	..	..
India[e]	7 260	9 000	11 000
Sri Lanka	11 497	13 608	..
Brazil	132	..	..
Republic of South Africa	18 000[e]	42 000	44 000
Other countries	48 383	33 000	79 000
Total	380 833	374 608	414 000

Sources: U.S. Bureau of Mines, **Minerals Yearbook Preprint, 1978-79**; U.S. Bureau of Mines, Mineral Commodity Summaries, January 1981.

P Preliminary; [e] Estimated; .. Not available; - Nil.

In the sulphate process, ilmenite is digested in concentrated sulphuric acid to produce a solution which is then clarified to remove insoluble heavy metals and impurities. After cooling, the iron is precipitated in the form of hydrated iron sulphate and the remaining liquid is hydrolysed to form insoluble hydrated titanium dioxide. The latter is precipitated by the addition of seed crystals. The precipitate is washed and calcined to obtain titanium dioxide. In the chloride process, rutile is chlorinated in the presence of carbon to produce titanium tetrachloride. The tetrachloride is separated from other chloride products by distillation and then vaporized and oxidized to produce titanium dioxide and chlorine. The chlorine is recovered and recycled.

More than one-half of the TiO_2 pigment produced is consumed by the paint industry and an additional one-quarter by the paper industry. The remainder is consumed in the manufacture of plastic, rubber, textiles, floor-coatings, ceramics and inks.

Some 10 per cent of the titanium ore produced is used in the production of titanium metal. Titanium sponge, an intermediate form of the metal, is produced by reducing purified titanium tetrachloride, obtained from the chloride process, with sodium or magnesium in an inert atmosphere. Residual chlorides are removed and the sponge metal is compacted and melted into metal ingots. The production of 1 kg of titanium sponge metal requires approximately 2.2 kg of rutile, 3.5 kg of chlorine, 1.3 kg of magnesium or 2.1 kg of sodium, 0.3 kg of petroleum coke and 8 495 cubic centimetres of inert gas, as well as about 465 mega joules (MJ) of energy; the energy needed to produce the magnesium and chlorine is included in the foregoing. An additional 49 to 61 MJ of energy are required for the conversion of sponge to titanium metal ingot[1].

The demand for titanium metal is closely linked to the aerospace industry, which requires titanium metal and alloys because of their high strength-to-weight ratio. However, the potential application of titanium metal products in thermal and nuclear power plants as well as marine-related applications such as desalinization plants or offshore drill rigs will play a larger part in future demand forecasts for titanium.

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[1] United States Bureau of Mines, United States Department of the Interior. MCP-18 **Titanium** p 14, 1978.

OUTLOOK

Very little change is expected in the short- to medium-term market for titanium dioxide pigments. The major consuming industries, namely those producing paints, paper and plastics, will likely continue to experience slow growth. Installed producer capacity is adequate to satisfy modest demand growth.

The outlook for titanium metal is somewhat unclear. The added capacity for titanium sponge announced during 1980 by the major producers in both the United States and Japan has relieved the supply problems experienced in 1979. While an oversupply could develop in the medium-term if planned expansions come on-stream, new applications in sectors other than the aerospace industry could absorb the projected increase in production output.

PRICES

Prices of selected titanium commodities, in United States currency, 1980

	($)
Titanium ore, fob cars Atlantic and Great Lake ports[1]	
Rutile, 96%, per short ton, delivered within 12 months	425.00-450.00
Ilmenite, 54%, per long ton, shiploads	55.00
Slag, 70%, per long ton, fob Quebec	115.00
Titanium metal, sponge, per lb, max. 115 Brinell, 99.3% 500-lb lots[1]	7.02
Mill products, per lb delivered, 4,000-lb lots[1]	
Billet, Ti - 6AL-4V (8 in. diameter, rotating grade)	5.24-7.13
Bar, Ti - 6AL-4V (2 in. diameter, random lengths)	8.17-10.73
Titanium dioxide, anatase, dry milled, Canadian dollars[2]	
Bags, carlots, delivered eastern Canada, per kg.	1.533
Bags, carlots, rutile, per kg.	1.410

[1] **Metals Week**, December 29, 1980. [2] **CPI Management Service**, December 1, 1980.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
32900-1	Titanium ore	free	free	free	free
34715-1	Sponge and sponge briquettes, ingots, blooms, slabs, billets, and castings in the rough, of titanium or titanium alloys for use in Canadian manufactures (expires June 30, 1981)	free	free	25	free
34735-1	Tubing of titanium or titanium alloys for use in Canadian manufactures (expires February 28, 1981)	free	free	25	free

TARIFFS (cont'd)

CANADA (cont'd)

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
34736-1	Sheet, strip or plate of titanium or titanium alloys, cold-rolled, not more than 0.2015 inch in thickness, for use in the manufacture of tubes (expires June 30, 1981)	free	free	25	free
34745-1	Bars, rods, plate, sheet, strip, foil, wire, coated or not; forgings and mesh of titanium or titanium alloys, for use in Canadian manufactures (expires June 30, 1981)	7.5	7.5	25	5
37506-1	Ferrotitanium	free	5	5	free
92825-1	Titanium oxides	free	12.2	25	free
93207-6	Titanium whites, not including pure titanium dioxide	free	12.2	25	free

MFN Reductions under GATT (effective January 1 of year given)

	1980	1981	1982	1983	1984	1985	1986	1987
				(%)				
37506-1	5.0	5.0	4.8	4.7	4.5	4.3	4.2	4.0
92825-1	12.2	11.9	11.6	11.3	10.9	10.6	10.3	10.0
93207-6	12.2	11.9	11.6	11.3	10.9	10.6	10.3	10.0

UNITED STATES (MFN)

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
					(%)				
422.30	Titanium compounds	7.2	6.9	6.5	6.2	5.9	5.6	5.2	4.9
473.70	Titanium dioxide	7.3	7.1	6.9	6.8	6.6	6.4	6.2	6.0
601.51	Titanium ore	Remains free							
606.46	Ferrotitanium and ferrosilicon titanium	5.0	5.0	4.8	4.6	4.4	4.1	3.9	3.7
629.12	Titanium metal, waste and scrap[1]	16.7	15.3	14.0	12.6	11.3	9.9	8.6	7.2
629.14	Titanium metal, unwrought	18.0	18.0	17.5	17.0	16.5	16.0	15.5	15.0
629.20	Titanium metal, wrought	18.0	18.0	17.5	17.0	16.5	16.0	15.5	15.0

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated (1980), USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241.

[1] Duty on waste and scrap temporarily suspended.

Tungsten

D.G. LAW-WEST

CANADIAN DEVELOPMENTS

Canada Tungsten Mining Corporation Limited (Cantung), the only producer of tungsten ore in Canada, had a record year in 1980. Total 1980 production from the mine was 401 000 metric ton units (mtu) of tungsten trioxide (WO_3) from 317 000 tonnes (t) of ore grading 1.45 per cent WO_3, which compared with 1979 production of 328 000 mtu WO_3 from 247 000 t of ore grading 1.58 per cent WO_3. Tungsten recovery in 1980 increased to 87 per cent, a reflection of the efficiency of the expanded milling circuit on lower grade ore. Production would have been higher except for a labour dispute which started on November 14. The members of two locals of the United Steel Workers of America (USWA) went on strike, mainly for higher wages and better housing conditions. The lengthy strike was still in progress at year-end 1980. However, the company was able to fill customer orders from stocks to the end of the year.

In New Brunswick, construction began on the $80 million Mount Pleasant tungsten-molybdenum mine. The project is a joint venture between Billiton Canada Ltd. and Brunswick Tin Mines Limited. The latter is owned 89 per cent by Sullivan Mining Group Ltd. and 11 per cent by Mount Pleasant Mines Limited. Initial work included site clearing and leveling, as well as pouring some of the mill foundation. Underground work focused on two declines, a service opening and a conveyorway for raising ore from the underground crusher to the 2 000 tpd mill. Construction of the mine, mill and other surface facilities is expected to be completed by mid-1982. Two hundred permanent job positions will be created when the project becomes operational.

Amax of Canada Limited is expected to make a production decision sometime in early 1981 on its Mactung tungsten deposit in the MacMillan Pass area on the Yukon-Northwest Territories border. A feasibility study for a 1 000 tpd underground operation, which would employ about 250 people, is to be completed by early-1981. Underground development work and bulk sampling have outlined reserves of 30 million t grading 0.96 per cent WO_3.

Amax is also carrying out detailed exploration on the low-grade, tungsten-molybdenum, Logtung deposit on the British Columbia-Yukon border. Previous work indicated reserves of 179 million t grading 0.13 per cent tungsten and 0.052 per cent molybdenum. Bulk sampling and metallurgical testing were done during the year.

INTERNATIONAL DEVELOPMENTS

Total Western World tungsten production increased by about 3 per cent in 1980 compared with 1979. Major producers, including Australia, Canada, Portugal and the United States, all reported increased production. However, the remaining 21 minor producer countries collectively produced 8 per cent less tungsten.

TABLE 1. CANADA, TUNGSTEN PRODUCTION, IMPORTS AND CONSUMPTION, 1979 AND 1980

	1979		1980P	
	(kg)	($)	(kg)	($)
Production[1] (WO$_3$)	3 275 082	..	4 650 000	..
Imports				
Tungsten in ores and concentrates				
United States	11 000	242,000	6 000	107,000
Total	11 000	242,000	6 000	107,000
Ferrotungsten[2]				
United States	7 000	171,000	2 000	56,000
United Kingdom	21 000	425,000	-	-
Other countries	-	-	6 000	101,000
Total	28 000	596,000	8 000	157,000
Tungsten carbide powder				
United States	389 000	10,238,000	333 000	9,719,000
United Kingdom	33 000	558,000	..	..
West Germany	..	..	6 000	202,000
Total	512 000	14,479,000	422 000	11,981,000
	(number)	($)	(number)	($)
Tungsten carbide rotary rock drill bits				
United States	1 955	7,567,000	2 803	9,847,000
Other countries	1 259	233,000	182	972,000
Total	3 214	7,800,000	2 985	10,819,000
Tungsten carbide percussion rock drill bits				
Ireland	98 028	1,921,000	51 391	1,087,000
United States	29 577	1,184,000	63 405	1,561,000
Other countries	4 362	112,000	291	51,000
Total	131 967	3,217,000	115 087	2,699,000
Tungsten carbide tools for metal work				
United States	..	5,327,000	..	5,387,000
Other countries	..	3,912,000	..	3,565,000
Total	..	9,239,000	..	8,952,000
	(kg)	($)	(kg)	($)
Consumption (W content)				
Tungsten metal and metal powder	193 963	..	..	..
Other tungsten products[3]	186 266	..	..	..
Total	380 229	..	..	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Producers' shipments. [2] Gross weight. [3] Includes tungsten ore, tungsten carbide and tungsten wire.
P Preliminary; .. Not available; - Nil.

In the United States, Utah International Inc., a subsidiary of General Electric Company, continued development and construction of the Springer Mine in Nevada. When completed in 1982, annual production capacity of the mine expressed in tungsten metal is expected to be 725 t. In addition to the mine, General Electric is also installing an ammonium paratungstate (APT) plant on the property.

Teledyne Wah Chang (TWCA) progressively advanced the production rate toward capacity output at its new Strawberry Mine in California. The rated capacity of the mine is 450 tpy of contained tungsten.

AMAX Inc. is contructing an APT plant at its molybdenum conversion facility at Fort Madison, Iowa. The plant has been designed to process a wide variety of tungsten concentrates, but its basic feed will be scheelite concentrates from Cantung.

In May 1980, the United States General Services Administration (GSA) increased stockpile objectives for four categories of tungsten products from 19 370 t (42.7 million pounds) to 26 800 t (59 Mlb). The goals for tungsten-bearing materials are: ore and concentrate - 25 150 t (55.45 Mlb) contained tungsten; metal powder - 725 t (1.6 Mlb); and carbide powder - 910 t (2 Mlb).

In Australia, Tasminex NL formed a joint venture with McIntyre Mines Limited of Canada to develop the Kara scheelite deposit in Tasmania. While no details on the timing or scale of production are available, a feasibility study showed that 1.1 million t of ore grading 0.73 per cent scheelite could be mined by open-pit.

Feasibility studies on the Hemerdon joint venture in the United Kingdom continued during 1980. The partners, Amax Exploration of U.K. Inc. and Hemerdon Mining & Smelting (U.K.) Ltd., started pilot plant tests based on a proposed flowsheet to produce a marketable grade of concentrate. A decision on whether to bring the property into production is expected before the middle of 1981. Commercial production could begin within four years if the principals decide to proceed with the project.

USES

Tungsten materials can be divided into several major classes, depending upon the product form and its use. The main product classes include tungsten carbides, tungsten-bearing steels, superalloys and nonferrous alloys, mill products made essentially from pure metal, and chemicals.

Tungsten carbide (WC) is one of the hardest materials known and accordingly, has widespread applications where intense wear and abrasion are encountered. This product is the preferred metalworking material for the cutting edges of machine tools and as a metal surface in forming and shaping dies. It is produced by the chemical combination of tungsten metal powder and finely divided carbon. Tungsten carbide is compacted to the desired form, using cobalt as a binder, and sintered to produce cemented tungsten carbide. Cutting tools of cemented tungsten carbide are used for machining steel, cast iron and nonferrous metals, and for shaping in the woodworking and plastics industries. Cemented tungsten carbide is also used to make dies for wire and tube drawing, punches and dies for metal forming, and bits and tools for drilling equipments and wear-resistant parts. With the addition of tantalum, titanium and columbium carbides, the coefficient of friction of cemented tungsten carbides is lowered, thereby producing grades better suited to the machining of specific products, particularly steel products. Other uses of tungsten carbide are in tire studs, spikes for golf shoes, armour-piercing projectiles and welding electrodes.

As an alloy constituent, tungsten is used primarily in the production of high-speed steels, and tool and die steels. Tungsten is added to steels either as ferrotungsten (80 per cent tungsten), melting base (30-35 per cent tungsten), scheelite ($CaWO_4$) or as tungsten-bearing scrap. Tungsten-bearing steels are used for the same applications as carbides, especially where lower operating temperatures are encountered, although tungsten is also used in some stainless steels for application in high-temperature environments.

Tungsten is an important constitutent in a wide variety of superalloys and nonferrous alloys. Tungsten-containing superalloys are being used increasingly in high-temperature applications and in highly corrosive environments because of their high-temperature strength and oxidation resistance. In making the alloys, tungsten is usually added in the form of tungsten metal powder, although tungsten scrap can be used to satisfy part of the tungsten requirements. Superalloys can be classified into three

TABLE 2. CANADA, TUNGSTEN PRODUCTION, TRADE AND CONSUMPTION, 1970, 1975-80

	Production[1]	Imports		Consumption
	WO_3 content	Tungsten Ore[2]	Ferro-tungsten[3]	W content
	(kilograms)			
1970	1 690 448	82 645	90 718	446 687
1975	1 477 731	1 000	45 359	451 336
1976	2 168 153	-	77 111	337 345
1977	2 284 409	-	103 000	449 365
1978	2 885 619	1 200	73 000	388 146
1979	3 275 082	11 000	28 000	380 229
1980P	4 650 000	6 000	8 000	..

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] Producers' shipments of scheelite (WO_3 content); [2] W content; [3] Gross weight.
P Preliminary; - Nil; .. Not available.

TABLE 3. WORLD TUNGSTEN PRODUCTION IN ORES AND CONCENTRATES, 1978-80

	1978	1979	1980[e]
	(tonnes of contained tungsten: W content)		
Czechoslovakia[e]	80	80	80
France	608	500	577
Portugal	1 088	1 370	1 557
Spain	350	395	366
Sweden	580	371	371
Turkey	9	61	70
U.S.S.R.[e]	8 500	8 620	8 500
Total Europe	11 215	11 397	11 521
Canada	2 288	2 597	2 597
Mexico	185	200	200
United States	3 128	3 013	3 013
Total North America	5 601	5 810	5 810
Argentina	96	59	39
Bolivia	3 170	2 647	2 647
Brazil	1 165[r]	1 177	1 177
Peru	582	550[e]	550
Total South America	5 013	4 433	4 413
Burundi[e]	2	2	2
Namibia[e]	150	163	163
Southern Rhodesia[e]	25	30	30
Rwanda	385[r]	385	385
Uganda[e]	110	110	110
Zaire	148[r]	150[e]	150
Total Africa	820	840	840
Burma	323[r]	413	476
People's Republic of China[e]	12 000	12 000	13 000
Hong Kong[e]	5	5	5
India	21	20	20
Japan	754	751	668
Democratic People's Republic of Korea[e]	2 150	2 150	2 150
Republic of Korea	2 589	2 617	2 617
Malaysia	72[r]	68	68
Thailand	3 186	1 826	1 615
Total Asia	20 777	19 850	20 619
Australia	2 680	3 138	3 163
World Total	46 106	45 498	46 366

Sources: UNCTAD Tungsten Statistics, July 1981; Energy, Mines and Resources Canada.

[e] Estimated; [r] Revised; - Nil.

principal types: nickel base, iron base and cobalt base or "Stellite" superalloys. While only small amounts of tungsten are currently used in the nickel and iron base superalloys, several companies are developing new superalloys containing larger amounts of tungsten, a factor which could significantly expand the market for tungsten.

Mill products made from pure or nearly pure tungsten metal powder are used in significant quantities by the electrical industries. The relevant important properties of tungsten for electrical applications include its high-melting point, low-vapour pressure, hardness, good electrical conductivity and low coefficient of thermal expansion. Tungsten mill products such as rods, wire and flat products are made by compressing tungsten metal powder into the desired shape and then sintering.

Discs cut from tungsten rods are used as electrical contacts to improve resistance to heat deformation resulting from sparking and associated high temperatures. Pure tungsten contacts are used principally in ignition circuits of automobiles and aircraft.

However, the trend to electronic ignition systems without tungsten contacts has resulted in a decline in its use for this application. Tungsten discs are also used as heat sinks in semiconductor applications and, in combination with other elements, as electrical contacts and breakers for industrial use.

Tungsten wire is used for filaments in incandescent lamps, and heating elements in both fluorescent lamps and vacuum tubes. The overall demand for tungsten wire is increasing in response to the upward trend in the manufacture of lamps and new uses such as de-icing and defogging elements in automobile windshields.

Flat products are used for various parts of electron tubes and radiation shields as well as for very high-temperature applications in reducing or inert atmospheres.

Tungsten is used for counterweights and balances, especially by the aircraft industry, but it is being replaced by depleted uranium, which has about the same density.

Minor amounts of tungsten are used to make chemicals and compounds for non-metallurgical applications. Some of the end-uses include dyes, toners, phosphors, chemical reagents, corrosion inhibitors and catalysts.

PRICE STABILIZATION

The Twelfth Session of the United Nations Committee on Tungsten was held in Geneva, Switzerland from February 25-29, 1980. Progress has been slow in these international discussions and the Twelfth Session accomplished little else beyond establishing that positions of the various delegates had remained unchanged. The three fundamental positions that evolved from an earlier meeting in September 1979, the second meeting of the Preparatory Working Group on Tungsten (PWG), are:

- most major producing countries, excluding Canada, are in favour of establishing an International Commodity Agreement (ICA) with binding economic provisions.
- most major consuming countries support the creation of a producer-consumer consultative forum (PCCF).
- France has proposed, as a compromise solution, a formal mechanism that does not initially have the range of economic provisions normally associated with a commodity agreement, but which has provisions for adding economic measures at a later date. This third position received more producer country support than when it was initially proposed at a meeting in 1978.

The Twelfth Session ended with a recommendation that a further meeting be held late in 1980 or in 1981.

PRICES

Tungsten prices increased slightly from 1979 levels. The average price during 1980, as calculated by the **Metal Bulletin** was $144.41 per mtu WO_3 up 4 per cent from $138.83 in 1979.

The International Tungsten Indicator (ITI) in its second full year of operation, averaged $142.69 per mtu WO_3 on transactions covering 1.4 million mtu WO_3. In 1980 the ITI gained wider acceptability and recognition when the United States Justice Department decided that U.S. companies could contribute to the indicator without breaking anti-trust laws.

OUTLOOK

Tungsten markets are expected to become more buoyant throughout 1981, in part due to energy-related projects. A particularly strong market is in exploration activities which consume large amounts of tungsten in the search for fuels and minerals.

The supply and demand of tungsten were closely balanced at the end of 1980 and prices should remain relatively stable throughout 1981. Historically the price of tungsten has experienced extreme fluctuations during times of market imbalance.

In the longer term, developments now under way could create a situation for market instability. Large new production capacities are coming on-stream in both Canada and the United States while tungsten scrap recycling is increasing. The anticipated imbalance between supply and consumption could be offset by the recent change in the U.S. stockpile objective for tungsten. As the United States acquires tungsten to achieve higher stockpile objectives, less tungsten will be available for purchase from producers and U.S. consumers will no longer be able to count on stockpile releases for their requirements.

In spite of these potential problem areas, increased attention to market conditions by both consumers and producers in recent years has shown that serious supply and demand disequilibrium can be avoided. Such a responsible approach adds support for the view that the tungsten industry will continue to achieve a stable growth rate in the future.

PRICES

Tungsten Prices quoted in **Metals Week**

	December 31, 1979	December 31, 1980
	($US)	
Tungsten ore, 65% minimum WO_3		
G.S.A. domestic, duty excluded, per short ton unit of WO_3	118.29	127.46-128.36
G.S.A. export, per short ton unit of WO_3	120.87	127.52
L.M.B. ore quoted by **London Metal Bulletin**, cif Europe, per metric ton unit of WO_3	128.00-133.00	142.00-145.00
Ferrotungsten, per pound W, fob Niagara Falls, low-molybdenum	11.55	11.90
Tungsten metal, per pound, fob shipping point		
Hydrogen reduced: 99.5%, depending on Fisher No. range	13.90-15.50	13.90-15.50

cif Cost, insurance and freight; fob Free on board.

TARIFFS

CANADA

		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
32900-1	Tungsten ores and concentrates	free	free	free	free
34700-1	Tungsten metal in lumps, powder, ingots, blocks or bars and scrap of tungsten alloy metal, for alloying purposes	free	free	free	free

TARIFFS (cont'd)

		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
CANADA (cont'd)					
34710-1	Tungsten rod and tungsten wire	free	free	25	free
35120-1	Tungsten and alloys in powder, pellets, scrap, ingots, sheets, strips, plates, bars, rods, tubing, wire, for use in Canadian manufactures (expires June 30, 1981)	free	free	25	free
37506-1	Ferrotungsten	free	5	5	free
37520-1	Tungsten oxide in powder, lumps and briquettes, for use in the manufacture of iron and steel	free	free	5	free
82900-1	Tungsten carbide in metal tubes for use in Canadian manufactures	free	free	free	free

MFN Reductions under GATT (effective January 1 of year given)

	1980	1981	1982	1983	1984	1985	1986	1987
				(%)				
37506-1	5.0	5.0	4.8	4.7	4.5	4.3	4.2	4.0

UNITED STATES (MFN)

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
				(% unless otherwise specified)					
422.40	Tungsten carbide, on tungsten content	16¢/ lb + 12.5%	10¢/ lb + 12.5%	5¢/ lb + 12.5%	12.5	12.0	11.5	11.0	10.5
422.42	Other tungsten compounds	11.7	11.4	11.2	11.0	10.7	10.5	10.2	10.0
601.54	Tungsten ore, per pound, tungsten content	17¢			- no change -				17¢
606.48	Ferrotungsten and ferro-silicon tungsten, on tungsten content	21¢/ lb + 6%	21¢/ lb + 6%	8.8	8.2	7.5	6.9	6.2	5.6
629.25	Tungsten metal waste and scrap, not over 50% tungsten	7.3	6.9	6.6	6.3	5.9	5.6	5.2	4.9
629.26	Tungsten metal waste and scrap, over 50% tungsten	7.5	4.5	4.2	4.2	4.2	4.2	4.2	4.2
629.28	Tungsten metal, unwrought, other than alloys: lumps grains and powders, on tungsten content	21¢/ lb + 12.5%	21¢/ lb + 12.5%	15¢/ lb + 12.5%	9¢/ lb + 12.5%	3¢/ lb + 12.5%	12.1	11.3	10.5
629.29	Tungsten metal, unwrought, other than alloys: ingots and shot	10.5	10.5	9.8	9.0	8.3	7.5	6.8	6.0

TARIFFS (cont'd)

UNITED STATES (cont'd)

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
				(% unless otherwise specified)					
629.30	Other unwrought tungsten metal	12.5	12.5	11.5	10.5	9.6	8.6	7.6	6.6
629.32	Unwrought tungsten alloys, not over 50% tungsten	6.7	6.4	6.1	5.9	5.6	5.3	5.0	4.7
629.33	Unwrought tungsten alloys, over 50% tungsten	12.5	12.5	11.5	10.5	9.6	8.6	7.6	6.6
629.35	Unwrought tungsten metal	11.8	11.0	10.3	9.5	8.8	8.0	7.3	6.5

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated (1980), USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241.

Uranium

R.T. WHILLANS

The uranium industry faced diminishing short-term prospects in 1980, brought about by a decline in prices and downward revisions to nuclear power growth projections, and leading to a general moderation in activity. Many companies, particularly in the United States, reduced their level of production, and there were some reports of mine closures and deferrals of development projects. Despite the deteriorating short-term outlook, longer-term opportunities sustained exploration efforts in many countries, and some companies moved to acquire properties with the potential for future development.

In Canada, uranium exploration and development momentum was generally maintained, with the focus in Saskatchewan, where one new facility commenced production and several potentially important new discoveries were announced. The summary session of the Saskatchewan Key Lake Board of Inquiry was completed in October, and recommendations regarding the conditions under which the Key Lake mine and mill development could proceed were expected in early-1981. Also of significance was the commencement in Calgary of Canada's first commercial project for the recovery of uranium as a byproduct of phosphoric acid production.

On a less positive note, a major fire destroyed part of Denison Mines Limited's new mill facility at Elliot Lake. In Labrador (Newfoundland), development of the Kitts-Michelin project was deferred pending improved market conditions and further consideration of the environmental implications of the development. In British Columbia, the provincial government imposed a seven-year moratorium on all uranium exploration and development activity in the province.

Results of the International Nuclear Fuel Cycle Evaluation (INFCE), a major international study on the long-term growth of nuclear power, were released early in 1980. The study indicated that potential uranium supply would exceed requirements by a significant margin throughout the remainder of the decade. Events since the INFCE results were released augmented this imbalance and no improvement in the situation was evident at year-end.

As it continues to be apparent that nuclear energy must play a significant role in contributing to the world's future energy needs, long-term market prospects remained promising. For example, most estimates of nuclear power growth still indicated a doubling of installed capacity before the end of the decade. Canada's current uranium producing capabilities, together with the uranium industry's potential for expansion, should ensure that Canada's position as an important supplier to world markets will be maintained.

PRODUCTION AND DEVELOPMENT

Production of uranium in Canada in 1980 amounted to 7 152^r tonnes (t) of uranium (U)[1], compared to 6 817 t U in 1979. Six

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[r] Revised.

[1] One metric ton of elemental uranium (tonne U) is equivalent to 1.2999 short tons of uranium oxide (U_3O_8).

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operators produced uranium concentrates throughout the year, and two new facilities, one of them a "byproduct" operation, started production by year-end. Shipments of uranium made by the "primary" producers from production or inventory totalled some 6 739 t U, valued at $702 million; final shipments for 1979 were reported at 6 530 t U, valued at $616,168,384 (Table 1). Of Canada's total uranium shipments in 1980, some 67 per cent was from four Ontario producers, the two largest being in the Elliot Lake area, with the remainder coming from Saskatchewan producers.

TABLE 1. URANIUM OUTPUT[1] IN CANADA BY PROVINCE, 1979 AND 1980

	1979		1980	
	(t)	($000)	(t)	($000)
Ontario	4 005	375,793	4 394	463,454
Saskatchewan	2 525	240,375	2 345	238,584
Total	6 530	616,168	6 739	702,038

Source: Energy, Mines and Resources Canada.

[1] Shipments of uranium (U) in concentrate from ore processing plants; one metric ton of elemental uranium (tonne U) is equivalent to 1.2999 short tons uranium oxide (U_3O_8).

The mill expansion project of Denison Mines Limited at Elliot Lake was set back six months as a result of a multi-million dollar fire in September that destroyed part of the new facility. The mill expansion, which had been scheduled for completion before the end of the year, will double the throughput capacity from 6 400 to 14 000 t of ore per day (tpd). Normal production continued at the existing mill which was not damaged by the blaze. During 1980 some 2 276 882 t of ore assaying 0.793 kg U per t were milled to produce 1 712 t U; recovery improved to 93.33 per cent despite lower ore grades. Other phases of the company's expansion program, including underground development work at the Denison mine and reopening of the adjoining Stanrock mine, which has been dewatered, will continue until completion in 1982 and 1985, respectively.

The bulk of Rio Algom Limited's production at Elliot Lake, continued to come from its 6 350 tpd Quirke mine and mill. Equipment problems during the start-up of the 2 990 tpd Panel mill in late-1979 were overcome and the operation contributed increasingly to production throughout the year. The Quirke mill processed some 2 208 100 t of ore, which included 85 275 t of Panel ore; average recovery was 0.890 kg U per t, or a record 95.5 per cent. Total output from the Quirke mill was 1 879 t U. The Panel mill processed some 912 630 t of ore, having reached its design capacity during the fourth quarter; average recovery increased to 0.721 kg U per t, or an improved 88.2 per cent. Total output from the Panel mill was 730 t U. Some 2 299 t U from both the Quirke and Panel operations were delivered to domestic and export customers. The rehabilitation of the company's[1] Stanleigh mine and mill, financed by Ontario Hydro, progressed on schedule and within budget. Full production, at a rate of 4 540 tpd, is expected in 1984. Given improved markets and appropriate financing, future development of the Milliken, Lacnor and Nordic properties which adjoin Stanleigh is possible.

At the underground and surface heap-leaching facility of Agnew Lake Mines Limited, 90 km east of Elliot Lake, production increased during the year despite the plan to phase out operations. Output totalled 195 t U compared to 172 t U produced in 1979. The decision to suspend mining was made late in 1979 and mining continued until the end of May 1980. As no new ore will be developed for leaching, recoveries will come from the leaching of broken rock in the underground stopes and on the surface stockpile. At year-end some 3 390 150 t were under leach, at which time the solution inventory contained an estimated 37 t U; overall extraction to date has been 45 per cent. The company, granted a two-year licence renewal by the Atomic Energy Control Board (AECB), must submit a plan and schedule for decommissioning the leaching and mill tailings area. The operation will continue until recoveries decline to a level where continued production becomes uneconomic.

Madawaska Mines Limited was able to maintain scheduled production at its 1 360 tpd operation at Bancroft, Ontario despite higher costs and declining uranium prices. A total of 360 211 t of ore was milled during the year at an average mill-head grade of

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[1] Rio Algom and Preston Mines Limited were amalgamated effective Janaury 30, 1980.

TABLE 2. URANIUM PRODUCTION IN CANADA, BY COMPANY, 1979 AND 1980

Company	Location	Production tonnes U 1979	 1980
Agnew Lake Mines Limited	Agnew Lake, Ont.	172	195
Cenex Limited	Uranium City, Sask.	43	-
Cluff Mining	Cluff Lake, Sask.	-	11
Denison Mines Limited	Elliot Lake, Ont.	1 729	1 712
Eldorado Nuclear Limited	Eldorado, Sask.	387	423[1]
Gulf Minerals Canada Limited[2]	Rabbit Lake, Sask.	2 065	1 967
Madawaska Mines Limited	Bancroft, Ont.	233	235
Rio Algom Limited - Quirke	Elliot Lake, Ont.	2 036[3]	1 879
- Panel		152[4]	730
Total Canada		6 817	7 152[5]

Source: Company annual reports.

[1] Includes 6 t U from Cenex Limited. [2] Joint operation with Uranerz Canada Limited. [3] Includes uranium from some 94 350 t of Panel ore processed during the preproduction period. [4] Includes 90 t U from preproduction ore. [5] Does not include output from ESI Resources Limited, byproduct uranium operation (see text).

0.687 kg U per t to produce 235 t U; overall recovery remained at about 95 per cent. Of particular interest was a limited reorganization of the company, whereby Madawaska retained a 51 per cent undivided interest in the assets and liabilities but became wholly-owned by Federal Resources Corporation, a U.S. company. Consolidated Canadian Faraday Limited acquired a direct owner-interest in the mine and facilities, and receives 49 per cent of the operating profit.

In Saskatchewan, output of uranium concentrates from Eldorado Nuclear Limited's Beaverlodge mill near Uranium City increased despite continued technical difficulties and a serious forest fire in the area which diverted manpower from production. The mine mechanization program which began late in 1979 resulted in modest improvements in output while production contributions from the Dubyna property, also brought on-stream late that year, helped to offset declines in other areas of production. During 1980, 292 113 t of ore, with an average grade of 1.59 kg U per t, were milled to produce 423 t U; average recovery increased to 88.6 per cent from 86.9 per cent in 1979.

In February it was agreed that Cluff Mining, a partnership owned 80 per cent by Amok Ltd. and 20 per cent by Saskatchewan Mining Development Corporation (SMDC), would be the name under which the Cluff Lake, Saskatchewan uranium project would operate. Mining of the high-grade "D" orebody, estimated to contain in excess of 5 000 t U, began on May 31 and by July construction of the mill was essentially completed. Concentrate production at the mill, where the uranium extraction process relies on direct precipitation of the yellowcake, started in October; by year-end some 11 t U had been produced. Development of the "D" orebody, or Phase 1, completed at costs close to the $80 million budgeted, will result in production at the rate of 1 500 t U a year.

An environmental impact study for Phase 2, the development of Cluff Mining's lower-grade Claude and "N" deposits, was in preparation and will be submitted to the Government of Saskatchewan by late 1981 for regulatory approval. Production from Phase 2 was planned for early 1984 at a reported capital cost approaching $100 million.

With the exception of some preparatory site-work, development at the Key Lake uranium project, 240 km north of La Ronge, Saskatchewan was suspended during much of 1980, pending the completion of a provincial inquiry established to recommend the conditions under which the project should be permitted to proceed. The summary hearings of the board of inquiry were completed on October 3, 1980 (see Government Affairs).

TABLE 3. PRODUCTION OF URANIUM IN CONCENTRATES BY MAJOR PRODUCING COUNTRIES, 1975-80

	United States	Canada	South Africa	Namibia	France	Niger	Gabon	Australia	Other[1]	Total[2]
					(tonnes U)					
1975	8 900	3 560	2 490	-	1 730	1 310	800	-	330	19 120
1976	9 800	4 850	2 760	650	1 870	1 460	..	360	340	22 090
1977	11 500	5 790	3 360	2 340	2 100	1 610	910	355	385	28 350
1978	14 200	6 800	3 960	2 700	2 180	2 060	1 020	515	455	33 890
1979	14 400	6 820	4 800	3 840	2 360	3 620	1 100	705	465	38 110
1980	16 800	7 150	6 150	4 040	2 630	4 100	1 030	1 560	510	43 970

Sources: Data derived principally from **Uranium: Resources, Production and Demand** a biennial report jointly produced by the Nuclear Energy Agency of the Organization for Economic Co-operation and Development, and the International Atomic Energy Agency.

[1] Includes Argentina, West Germany, Japan, Portugal, Spain, and Sweden (1975 only).
[2] Totals (rounded) are of listed figures only.
- Nil; .. Not available.

Key Lake Mining Corporation (KLMC), formed in 1979 and jointly owned by SMDC (one-half), Uranerz Exploration and Mining Limited (one-third), and Eldor Resources Limited, wholly-owned by Eldorado Nuclear, (one-sixth), plans to exploit the Gaertner deposit first. Construction of the mill, which would process as much as 700 tpd, could begin in 1981 with first production from the open-pit operation by the summer of 1983; annual output could reach 4 600 t U a year by 1984. Combined reserves of the Gaertner and Deilmann deposits reportedly exceed 59 000 t U. Capital costs for the project are likely to approach $400 million. During the year, construction of a road to Key Lake was completed and it was opened to heavy-vehicle traffic.

Late in 1979, Canada Wide Mines Ltd., a wholly-owned subsidiary of Esso Resources Canada Limited, took over the management of Esso Minerals Canada's Midwest Lake uranium project, some 24 km west of Rabbit Lake, Saskatchewan (Esso Minerals is a Division of Esso Resources Canada). At the property, owned by Esso Minerals (50 per cent), Numac Oil & Gas Ltd. (25 per cent), Bow Valley Industries Ltd. (12½ per cent), and Midwest Mining Corporation/Mink Mining Corporation (12½ per cent), drilling efforts continued, as work on the environmental impact statement and feasibility studies progressed. It was thought that open-pit methods might be used to mine the high-grade portions of the deposit and that a mill of some 700 tpd could produce about 1 700 t U a year. Contingent on early regulatory approval and the availability of markets, mine development was expected in 1982, although production was not anticipated before 1986. Total capital cost of the project was reported at $400 million.

Gulf Minerals Canada Limited reached the half-way point in the exploitation of the Rabbit Lake open-pit in northern Saskatchewan, a joint operation with Uranerz Canada Limited (Gulf 51 per cent - Uranerz 49 per cent). During 1980, 665 730 t of ore, with an average grade of 3.13 kg U per t, were milled to produce 1 967 t U, of which Gulf's share was about 1 003 t U. Mill throughput was increased slightly to compensate for lower-grade ore, and mill recovery was maintained at 94.4 per cent. Gulf plans to develop its Collins Bay "B" orebody in order to maintain production capacity at the 1 500 tpd Rabbit Lake mill, and in June submitted an environmental impact statement to the Saskatchewan government. At year-end, Gulf's proposal was still under consideration by the government. Mining of the Collins Bay "B" deposit, located some 11 km north of Rabbit Lake, could began by 1982 although it was not expected that milling would begin before 1983. The presence of base-metal oxides and arsenides in the "B" ore will necessitate the modification of the uranium extraction circuits at the Rabbit Lake plant.

In its 1979 annual report, Brinco Limited indicated that its subsidiary, Brinex Limited would not likely proceed in 1980 with the development of its Kitts-Michelin project in eastern Labrador because of the depressed uranium market. Subsequently, it was announced by the province that a development licence for the project would be withheld (see Government Affairs). In the fall, Edison Development Canada Inc., purchased Urangesellschaft Canada Limited's 40 per cent interest in the project for a reported $US 10.1 million. At year-end, approval by the federal government had been given for the acquisition of 50.1 per cent of the issued voting shares of Brinco Limited by Olympia & York Developments Limited of Toronto, a move which increased Canadian ownership of Brinco from 28 to 73 per cent.

ESI Resources Limited, a wholly-owned subsidiary of Earth Sciences Incorporated of Golden, Colorado, received approval early in the year to recover uranium as a byproduct of phosphoric acid production at the Calgary, Alberta plant of Western Co-operative Fertilizers Limited (WCFL). ESI's recovery plant, the first such operation in Canada, was built adjacent to the fertilizer plant and designed to recover some 60 t U a year. The phosphate rock used by WCFL is imported from the United States; the uranium recovered will supply U.S. customers. Commissioning of the facility began in June 1980 and first production was realized by year-end. It was expected that the plant would reach production of some 40 t U a year early in 1981.

At the beginning of 1980, the work force at Canada's producing uranium operations totalled some 5,700 employees. Of this total about 2,700 worked in the mines, both open-pit and underground, and some 700 in the mills, with the balance described as general employees.

EXPLORATION

Significant uranium exploration effort, concentrated in Saskatchewan, was maintained in Canada during 1980 despite the deteriorating short-term uranium market outlook. Uranium exploration expenditures were expected to approach the $130 million level reached in 1979, as reported by Energy, Mines and Resources Canada (EMR) in its annual uranium exploration survey[1]. Of the 127 companies or joint ventures that responded to the EMR survey in 1979, 67 operators incurred uranium exploration expenditures, as did an additional 28 nonresponding, but nonetheless participating, joint-venture partners. The survey included essentially all the major companies involved in the 513 reported uranium exploration projects under way in Canada during 1979.

Of the 67 active operators, 27 each spent more than $1 million and together accounted for almost 90 per cent of the total expenditures. The 10 most active organizations, accounting for nearly half of the $130 million total, were in alphabetical order, Amok, Asamera Inc., Brinex, E & B Explorations Ltd., Eldorado Nuclear, Gulf Minerals, SERU Nuclear (Canada) Limited, SMDC, Uranerz Exploration and Mining Limited, and Urangesellschaft Canada Limited.

The survey also indicated that 483 300 m of uranium exploration and surface development drilling was completed during 1979, more than two-thirds of it in Saskatchewan; first estimates suggested the 1980 figure to be about 500 000 m.

Canadian Occidental Petroleum Ltd. and Inco Metals Company continued to evaluate their jointly-held McClean Lake deposit, 11 km northwest of Rabbit Lake, Saskatchewan. In May, a year after the original discovery was announced, details of a new mineralized zone were revealed. Drilling along the new McClean South zone, located half a kilometre south of the now-renamed McClean North zone, indicated uranium mineralization over a strike length of some 945 m, at a depth of about 150 m.

In February 1980 Gulf Minerals discovered a new uranium deposit in northeastern Saskatchewan, about 13 km north of the Gulf-Uranerz Rabbit Lake mine. Diamond drilling carried out on the Eagle Point prospect intersected uranium mineralization over a strike length of about 1 040 m, at depths up to 274 m. SMDC, Noranda Exploration Company, Limited and Gulf Minerals, the operator, each hold a one-third interest in the project; the joint venture continued exploration on two other properties west of Wollaston Lake.

Asamera Inc. announced the discovery of two new mineralized zones near its original Dawn Lake prospect in the Keefe Lake-Henday Lake area of northeastern Saskatchewan. Situated between Esso Minerals' Midwest Lake project and Gulf's

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[1] **Uranium in Canada: 1979 Assessment of Supply and Requirements,** Report EP 80-3, Energy, Mines and Resources Canada, September, 1980.

Rabbit Lake mine, the most recent discovery, Zone 11A, is one of four uranium-bearing zones outlined since 1978. SMDC holds a 50.75 per cent interest in the project, Asamera, the operator, has 25 per cent and the balance was held by Reserve Oil & Minerals Corp., E & B Explorations, SERU Nuclear, Crest Resources and Exploration Corporation, Kelvin Energy Ltd., and newcomer Phillips Petroleum Company Western Hemisphere.

At the McArthur River project, operated by SMDC, low-level uranium mineralization was encountered beneath the Athabasca sandstone; test drilling will continue in 1981.

In the Baker Lake area of the Northwest Territories encouraging exploration results sustained additional drilling efforts. At the South Bissett Creek zone, west of Bissett Lake, Pan Ocean Oil (Canada) Ltd. encountered near-surface mineralization amenable to open-pit development. Pan Ocean, the operator, which has drilled in the area since 1975, holds a 60.2 per cent interest in the new find. Its partners include Petrobec Inc. (17.1 per cent), Dynamic Mining Exploration Ltd. (14.1 per cent) and Lochiel Exploration Ltd. (8.6 per cent). Urangesellschaft was looking for Canadian partners to participate in property development following a successful summer drilling program east of the Main Zone of its Lone Gull property in the Sissons Lake area about 80 km west of Baker Lake. Initially outlined in 1978, the Main Zone was reported to contain an estimated 7 700 t U.

Although Saskatchewan remained the centre of activity, exploration programs continued in several other provinces across Canada with the exception of British Columbia, where the announcement of a seven-year moratorium on uranium mining and exploration stopped all such activity (see Government Affairs).

URANIUM RESOURCES

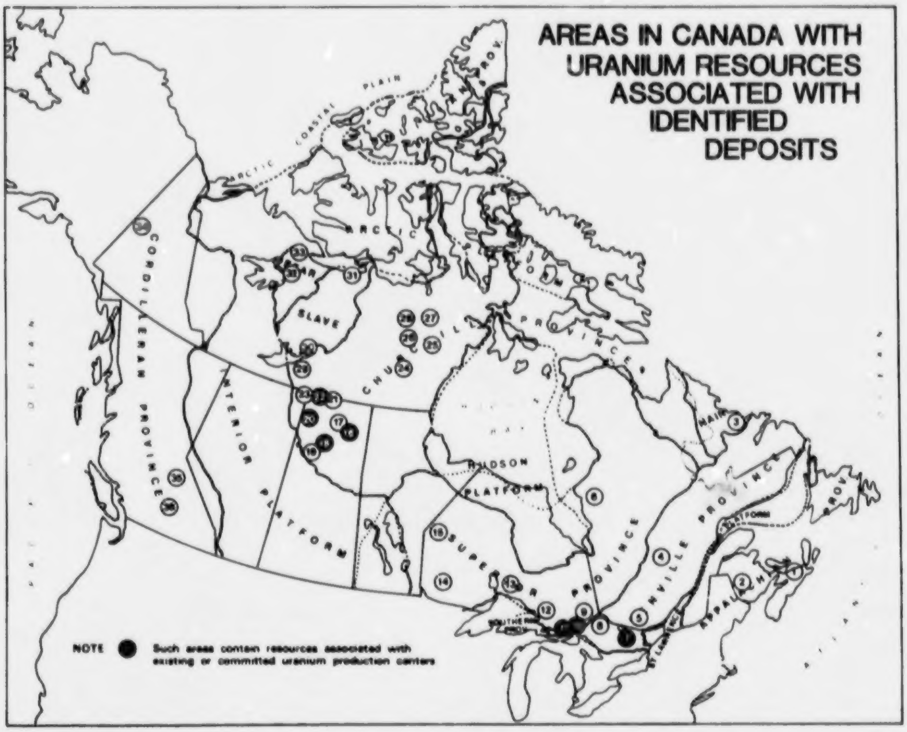
The Uranium Resource Appraisal Group (URAG) of EMR completed its sixth annual (1979) assessment early in 1980. Uranium resource estimates are divided by URAG into several separate categories which reflect different levels of confidence in the quantities reported. These categories are further divided into two levels of economic exploitability related to the current market price of uranium. The 1979 assessment was carried out using a lower price range, limited by the uranium market price estimated in Canadian dollars at $130/kg U, and a higher price range, spanning the $130-200/kg U interval. The $130/kg U price, determined in December 1979 when most of the data for the assessment was gathered, was the average weighted price for 1979 under market-related export contracts (including spot sales) made by Canadian producers for deliveries in 1979. The results of URAG's 1979 uranium resource assessment, completed in September 1980, are summarized in Table 4. Areas in Canada in which these resources occur are illustrated in Figure 1.

TABLE 4. 1979 ESTIMATES OF CANADA'S MINEABLE URANIUM RESOURCES

Resource Category	Mineable at prices up to $130/kg U[1]	Mineable at prices up to $200/kg U[2]
	(tonnes U contained in mineable ore)[3]	
(1) Measured	73 000	77 000
(2) Indicated	157 000	182 000
(1) + (2) = Reasonably Assured[4]	230 000	259 000
(3) Inferred	238 000	328 000
(4) Prognosticated	143 000	442 000
(3) + (4) = Estimated Additional[4]	381 000	770 000

Source: **Uranium in Canada: 1979 Assessment of Supply and Requirements;** Report EP80-3, Energy, Mines and Resources Canada, September 1980.

[1] $130/kg U (Canadian dollars) was the estimated uranium market price in December 1979 at the beginning of the assessment. [2] Includes resources mineable at prices up to $130/kg U. [3] 1 tonne (metric ton) U is equivalent to 1.2999 short tons U_3O_8. [4] International resource terms used by the Nuclear Energy Agency of OECD and the International Atomic Energy Agency; for purposes of international comparison, Canada's low and high "price" categories may be considered equivalent to the NEA/IAEA's low and high "cost" categories, respectively.


ARCTIC COASTAL PLAIN
ARCTIC PLATFORM
CORDILLERAN PROVINCE
SLAVE
CHURCHILL PROVINCE
INTERIOR PLATFORM
HUDSON PLATFORM
HUDSON BAY
SUPERIOR PROVINCE
GRENVILLE PROVINCE
NAIN
APPALACHIAN
ST. LAWRENCE
SOUTHERN
NOTE ● Such areas contain resources associated with existing or committed uranium production centers

AREAS IN CANADA WITH URANIUM RESOURCES ASSOCIATED WITH IDENTIFIED DEPOSITS

(numbers refer to locations on map above)

1. Cobequid Mountains
2. Lake George
3. Makkovik-Seal Lake
4. Crevier Alkalic Complex
5. Mont Laurier
6. Sakami Lake
7. Bancroft-Sharbot Lake
8. Lake Nipissing
9. Cobalt Embayment
10. Agnew Lake
11. Elliot Lake
12. Sault Ste-Marie - Montreal R.-Chapleau
13. Prairie River
14. Kenora-Dryden
15. Favourable Lake
16. Rabbit Lake - Collins Bay
17. Midwest Lake - McClean Lake
18. Key Lake
19. Wollaston Lake Belt
20. Carswell Structure (Cluff Lake)
21. Fond-du-Lac
22. Beaverlodge
23. Maurice Bay
24. Angikuni - Yathkeyd
25. Baker Lake
26. Schultz Lake
27. Amer Lake
28. Thelon Basin
29. Nonacho Lake
30. East Arm - Great Slave Lake
31. Bathurst Inlet
32. West Bear Province
33. Hornby Bay - Dismal Lakes
34. Central Yukon (Tombstone Mt.
35. Birch Island (Rexspar)
36. Kelowna-Beaverdell

Compared to estimates published the previous year, the 1979 combined[1] total of the measured, indicated and inferred resource categories was greater by 50 000 t U, representing a net increase of about 9 per cent. If production and the average processing recovery (93.2 per cent for existing conventional deposits) for 1979 are considered, the gross addition to resources amounted to some 57 300 t U, i.e. an increase of 10.3 per cent. The slight decrease in the measured category, after production of 6 817 t U, was more than offset by increases of 17 and 9 per cent respectively, in the indicated and inferred categories, reflecting continued evaluation of the Key Lake area as well as recent discoveries in the Eastern Rim of the Athabasca Basin (e.g. Collins Bay "B", Midwest Lake and McClean Lake). It is pertinent to note that as of January 1, 1980 almost 90 per cent of the total resources in the above three categories was associated with deposits that were either being mined or were committed for production.

Over 60 per cent of Canada's uranium resources in the measured, indicated and inferred categories occur in quartz-pebble conglomerates, primarily in the Elliot Lake and Agnew Lake areas of Ontario. Most of the remaining resources in the same three categories occur in vein and unconformity-related-type deposits, primarily in northern Saskatchewan.

Of the total resources referred to in Table 4, about 62 per cent is in Ontario and 33 per cent in Saskatchewan, whereas distributions quoted in the 1978 assessment were 68 and 27 per cent, respectively.

URAG also reported slight increases in both the prognosticated and speculative categories, reflecting increased potential for additional discoveries in areas that are favourable for uranium mineralization (Figure 2).

To provide a more meaningful illustration of uranium availability in its 1979 assessment, URAG prepared a projection of uranium production capability to 1990 that could be supported by the principal resource categories (i.e., Reasonably Assured plus Estimated Additional Resources). An adequate availability of manpower, equipment, capital financing, and the existence of base load contracts were assumed. URAG estimated that, under optimum conditions and supported by known deposits, Canadian production levels could increase to some 13 000 and 15 300 t U a year by 1985 and 1990, respectively. In contrast, annual domestic requirements were expected to grow from some 1 000 t U a year in 1980 to about 1 500 and 2 000 t U a year in 1985 and 1990, respectively.

Early in 1980 the Organization for Economic Co-operation and Development (OECD) released the results of the seventh in a series of world uranium supply assessments conducted jointly by the Nuclear Energy Agency (NEA) of OECD and the International Atomic Energy Agency (IAEA)[1]. The study showed that Canada accounted for some 12 per cent of the world's[2] "low-cost" Reasonably Assured Resources, ranking fourth behind Australia, South Africa, and the United States. Of greater significance in terms of Canada's future capability as a uranium supplier was its position with respect to Estimated Additional Resources. Of the world total of some 2.5 million t U reported in this category, in deposits mineable at "costs"[3] up to $US 130/kg U, Canada accounted for 30 per cent, ranking second behind the United States[4].

GOVERNMENT AFFAIRS

On February 27, 1980, the Government of British Columbia announced a seven-year moratorium on uranium exploration and mining in the province because of concern that these activities would do irreversible harm to the environment. As a result the Royal Commission of Inquiry into Health and Environmental Protection in Uranium Mining, established by the province once year earlier under Dr. David Bates to investigate the health and safety aspects of the uranium industry, was permitted to receive submissions until April 15 although no further hearings were scheduled. The Commission forwarded its final report to the government on October 31, 1980.

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[1] Only resources in the measured, indicated and inferred categories are considered for domestic allocation purposes.

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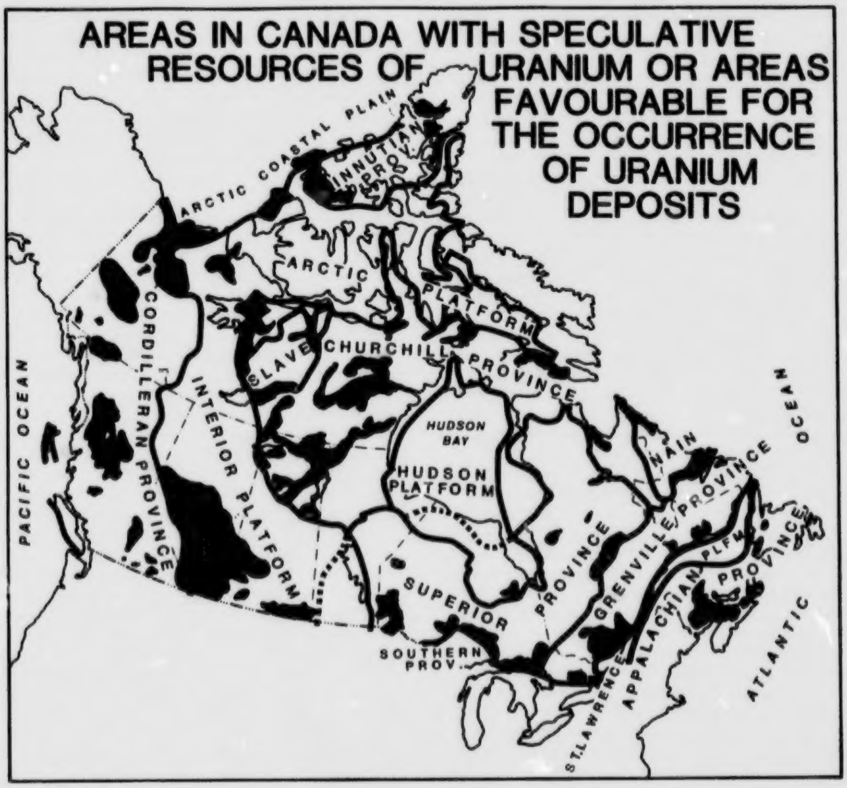
[1] **Uranium - Resources, Production and Demand**, NEA/IAEA, December 1979.

[2] Excluding the USSR, Eastern Europe and the People's Republic of China.

[3] See Footnote 4, Table 2.

[4] URAG's 1978 uranium data were incorporated into this world assessment.


AREAS IN CANADA WITH SPECULATIVE RESOURCES OF URANIUM OR AREAS FAVOURABLE FOR THE OCCURRENCE OF URANIUM DEPOSITS

ARCTIC COASTAL PLAIN
INNUITIAN PROV.
ARCTIC PLATFORM
CORDILLERAN PROVINCE
INTERIOR PLATFORM
SLAVE
CHURCHILL PROVINCE
HUDSON BAY
HUDSON PLATFORM
NAIN PROVINCE
SUPERIOR PROVINCE
SOUTHERN PROV.
GRENVILLE PROVINCE
APPALACHIAN PROVINCE
PLFM
ST. LAWRENCE
PACIFIC OCEAN
ATLANTIC OCEAN

In September a regulation was passed by the Government of British Columbia that was designed to stop all types of exploration and mining if significant quantities of uranium were discovered; the limit was set at 0.05 per cent uranium in isolated samples and 0.01 per cent at exploration sites, developed orebodies and producing mines. The regulation required that the percentage of uranium be reported to the chief inspector of mines within seven days of discovery and, following review, work be permitted to resume only where the uranium content was below the allowable limit. Operations where uranium was found associated with other mineralization would also be affected by the ruling.

In February, the Government of Saskatchewan appointed a five-member board of inquiry, chaired by Robert Mitchell, to decide under what conditions mine development at the proposed Key Lake uranium project should proceed. The Board had no mandate to examine the broader subject of uranium development in Saskatchewan, this question having been addressed by the Cluff Lake Board of Inquiry in 1977-78. No time restrictions were imposed on the proceedings, which passed through informal, formal and summary sessions between February and October.

The main causes of concern identified at the hearings were: the threat of arsenic contamination of the water supply by the mine-mill complex, the problems of waste (tailings) disposal and containment, the danger to workers exposed to excessive levels of radiation because of the high grade of the ore, and the possible environmental damage caused by the draining of eight lakes. The Board's recommendations were expected early in 1981.

The Uranium Royalties provisions, i.e. Part VI(A) of the Mineral Disposition Regulations under the Mineral Resources Act of Saskatchewan were extensively rewritten, primarily for purposes of clarification, and became effective as of March 1, 1980. These provisions first came into effect on August 1, 1976 to provide for royalty payments on uranium production from Crown lands.

The changes did not affect the magnitude of the royalties, the basic royalty remaining at 3 per cent of the gross sales of uranium production. The definition of "exploration expenditures" for purposes of the 3 per cent credit against graduated royalties was made more specific.

On March 26, the final report of Ontario's Royal Commission on Electric Power Planning, under the chairmanship of Dr. Arthur Porter, was released. Twenty-eight of its 88 recommendations dealt with nuclear power, concluding that nuclear energy has a continuing role to play in the expansion of Ontario Hydro's program. With respect to minimizing the risks of radiation exposure to uranium workers and to the general public, the Commission recommended that epidemiologic evaluation of Elliot Lake miners and uranium mill workers be undertaken on a continuing basis; that the province of Ontario contribute its share to any national uranium mine and mill waste program; that measures should be taken to ensure that such costs as long-term tailings monitoring, management and R&D be reflected in the cost of uranium fuel; and that further expansions in Ontario uranium mining and milling operations be contingent on demonstrated progress in R&D regarding tailings waste disposal.

On May 29, 1980, the Government of Newfoundland and Labrador announced that it had accepted the recommendation of the provincially appointed Environmental Assessment Board, chaired by C.W. Powell, that the development licence for the Kitts-Michelin project in Labrador be withheld until Brinex Limited demonstrated to the Board's satisfaction that it could and would safely dispose of the radioactive waste from its proposed mine and mill. It was emphasized that the decision was specific to the Kitts-Michelin project, and that the government was confident that the technological problems could be overcome so that the mining of uranium could proceed in the province.

In July 1980, the federal government introduced the Foreign Proceedings and Judgments Act (Bill C-41). Under this bill, where in the opinion of the Attorney General of Canada the recognition or enforcement of foreign judgments in anti-trust matters would harm Canada's interests with respect to international trade or commerce, the Attorney General may prevent the recogition or enforcement of such a judgment in Canada, or permit, in the case of a money judgment, the recognition or enforcement of that judgment for a reduced amount. The bill would permit in such cases a Canadian defendant to sue in Canada for, and recover from, the person in whose favour the foreign judgment had been rendered, any amount paid under such unenforceable foreign judgment. The bill would also permit the Attorney General of Canada to prevent the removal from Canada of documents and information in situations where in his opinion a foreign court attempts to exercise extra-territorial jurisdiction in a way that would adversely affect significant Canadian interests with respect to international trade or commerce. Upon promulgation, the bill would repeal the Uranium Information Security Regulations, enacted in September 1976 under the Atomic Energy Control Act, and subsequently amended in October 1977.

On August 6, 1980, a Federal Environmental Assessment Panel, chaired by John Klenavic, announced that it would not endorse the proposal by Eldorado Nuclear Limited to construct a $100 million uranium refinery at Warman, Saskatchewan, some 25 km northwest of Saskatoon, because of uncertainties with respect to the social impact of the refinery on nearby residents. This decision was taken in spite of the panel's conclusion that the refinery's impact on the physical environment would be minimal. Unable to negotiate a one-year extension, Eldorado dropped the option on the property a month later, but planned to consider alternative site possibilities in Saskatchewan.

The Ontario Legislature's Select Committee on Ontario Hydro Affairs examined the problem of radioactive waste management during 1980 and produced two reports. The first, **The Management of Nuclear Fuel Waste,** was tabled in June 1980 and the second, **Mining, Milling and Refining of Uranium in Ontario,** was tabled in December. The principal conclusions were that "many features of the Canada/Ontario Nuclear Fuel Waste Management Progam are sound" and that although "considerable improvement has been made in managing the short-term environmental consequences of uranium mines, the long-term problem remains to be solved".

Uranium Canada, Ltd. (UCAN), administrator of the Government of Canada's general uranium stockpile, stated in its annual report that at the end of 1980, the residual stockpile amounted to 5 572 t U in concentrates, of which some 578 t U were on loan to Eldor Resources Limited.

MARKETS AND PRICES

Despite increased marketing activity on the part of several Canadian producers in 1980, few new sales were obtained. New uranium export contracts totalling some 1 850 t U were reviewed by the federal government during the year and found to be consistent with Canadian uranium export policy. These contracts, representing sales to South Korea, Sweden, West Germany and the United States brought to some 59 000 t U the total amount of uranium under export contracts reviewed since September 5, 1974 (Table 5). The 59 000-tonne total reflects completed and scheduled deliveries under 50 contracts, only 19 of which were still active. As of December 1980, forward export commitments under all active contracts, including those in place prior to September 5, 1974, were estimated at some 48 500 t U; forward domestic commitments were about 80 000 t U.

Of particular significance were two agreements concluded by Rio Algom which will help to offset the abrogation by the Tennessee Valley Authority of its contract with Rio Algom for the purchase of some 6 540 t U between 1979 and 1990. The first, announced in May, called for the delivery of 1 603 t U to the Korea Electric Company over the period 1981 to 1990. The second, signed at year-end, stipulated delivery of 1 300 t U to Preussische Elektrizitäts AG, a West German utility, over a 13-year period starting in 1983.

As a result of the announced moratorium in British Columbia, the contract negotiated in 1979 for the sale of uranium to Korea Electric Company from the province's Blizzard deposit, which was to have been developed by Norcen Energy Resources Limited on behalf of several joint-venture partners including Ontario Hydro, was negated.

TABLE 5. URANIUM UNDER EXPORT CONTRACTS REVIEWED[1] SINCE SEPTEMBER 5, 1974 (as of December 1980)[2]

Country	short tons[3] U_3O_8	tonnes U
Belgium	1,220	938
Finland	2,300	1 769
France	2,000	1 538
Italy	1,800	1 385
Japan	25,358	19 507
South Korea	2,483	1 910
Spain	6,250	4 808
Sweden	1,178	906
Switzerland	200	154
United Kingdom	10,000	7 693
United States	15,640	12 032
West Germany	8,299	6 384
Total	76,728	59 024

Source: Energy, Mines and Resources Canada.

[1] Reviewed and found to be consistent with Canadian uranium export policy. [2] Quantities have been adjusted to reflect new and amended contracts. [3] Most Canadian uranium export contracts are written in terms of Imperial units.

In September 1980, an amendment to an Energy and Water Appropriations Act was introduced in the United States Senate which would have limited to 10 per cent the amount of foreign uranium that could be enriched for domestic use by U.S. utilities in United States Department of Energy (USDOE) enrichment plants. The measure was to have taken effect on October 1, 1980, and would have applied to all new USDOE enrichment contracts. Although the amendment was subsequently deleted from the bill by a joint Senate-House conference committee, it was agreed that the USDOE would prepare an analysis of the U.S. uranium industry to determine the potential impact of the import of foreign uranium. The analysis was expected to be completed in early 1981.

Passage of the amendment to the Appropriations Act would have counteracted a 1973 decision to phase out similar U.S. restrictions over the period 1977 to 1984. Under this phased removal, U.S. utilities' access to foreign uranium can increase from 30 per cent of their total enrichment plant feed material in 1980, to 40 per cent in 1981, 60 per cent in 1982, 80 per cent in 1983 and 100 per cent in 1984. In fact, during 1980 only some 8 per cent of U.S. utility purchases were of foreign origin.

Although prices for uranium had been relatively stable since mid-1976 at slightly more than \$US 104/kg U (\$US 40/lb U_3O_8), they began to decline in late 1979, and fell sharply in early 1980 as the short-term market outlook continued to deteriorate. During the first six months of the year, prices for immediate deliveries dropped by some 25 per cent to about \$US 78/kg U (\$US 30/lb U_3O_8). While the decline was largely attributable to a decrease in short-term market opportunities, it was also influenced by utility inventory sales, particularly in the United States, brought about by rising interest rates. By the end of December 1980 the price for immediate delivery as reflected by the Nuclear Exchange Corporation (NUEXCO) "Exchange Value"[1] had fallen to \$US 70.20/kg U (\$US 27/lb U_3O_8).

In a survey of U.S. uranium marketing activity, conducted by the USDOE and released in October, it was reported that the average price for uranium delivered in 1980 under all contracts, including those negotiated when price levels were extremely low, was \$US 67.60/kg U (\$US 26/lb U_3O_8). However, the average price reported under contracts that had provision for price renegotiation was higher, at \$US 102.57/kg U (\$US 39.45/lb U_3O_8). Such "market price" contracts accounted for 26 per cent of deliveries under all types of contracts, representing a growing proportion of total sales.

In Canada, market prices for 1980 deliveries of uranium were higher than those reflected by the NUEXCO Exchange Value. Calculations made in December, for the 1980 URAG exercise, indicated a price of \$Cdn 135/kg U which, if converted to US dollars at year-end exchange rates, would be equivalent to about \$US 114/kg U (\$US 44/lb U_3O_8). This price was the average weighted price under market-related export contracts (including spot sales) made by Canadian producers for deliveries in 1980. The \$Cdn 135/kg U value was established to define the lower price category for the purpose of URAG's 1980 assessment of Canada's uranium resources.

REFINING

From the record levels set the previous year, output of uranium hexafluoride (UF_6)[1] for light-water reactors and uranium dioxide (UO_2) for CANDU-type reactors decreased during 1980 at the Port Hope, Ontario, refinery of Eldorado Nuclear Limited. Some 4 246 t U as UF_6 were produced, down almost 6 per cent from the previous year. The refinery production problems that reduced throughput to the UF_6 conversion plant were resolved during the year and higher outputs were expected in 1981. Production of natural ceramic-grade uranium dioxide was 965 t U as UO_2, down about 37 per cent from 1979 and equivalent to output in 1978. The decline was the result of reduced fuel requirements for Ontario Hydro's reactor expansion program; requirements were forecast to increase in 1981. No production constraints were anticipated as a new UO_2 circuit, installed in 1979, was put into service during 1980.

At the end of 1979, preparatory site work had been completed at Eldorado's proposed new 9 000-tonne, integrated refining/conversion facility near Port Hope, Ontario. In April, the federal government announced that the project would be relocated to Blind River, Ontario to encourage industrial development in that area. As a result, Eldorado decided to construct a new 18 000-tonne refinery at Blind River and to commence a 9 000-tonne expansion of UF_6 conversion capacity at its existing Port Hope facility. The proposal would permit the phasing-out of the 25-year old Port Hope uranium trioxide (UO_3)[2] circuit, a tripling of UF_6 production capacity and, through the consolidation of production efforts, a reduction in transportation and maintenance costs associated with the operation of duplicate facilities. Site preparation at Blind River was completed by year-end and construction was scheduled to begin in early 1981; it was expected that both new facilities would be in production during 1984.

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[1] NUEXCO's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the last day of the month. NUEXCO is a private firm of uranium market analysts and brokers in the United States.

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[1] Uranium hexafluoride is the required feed material for the uranium enrichment process.
[2] Uranium trioxide is the initial refinery product from which either UO_2 or UF_6 is produced.

TABLE 6A. EXPORTS[1] OF RADIOACTIVE ORES AND CONCENTRATES[2] FROM CANADA, 1975-80

	United States[3]	United Kingdom	Japan	Italy	France	South Korea	Total
			($000)				
1975	28,129	21,987	986	-	-	-	51,101
1976	46,850	20,541	-	-	-	-	67,392
1977	72,848	2,590	-	-	-	-	75,438
1978	163,911	39,106	791	3,348	-	-	207,156
1979	347,388	18,851	9	12,613	-	-	378,862
1980	209,978	10,319	8,035	-	1	2,329	230,662

Source: Statistics Canada.

[1] Material that cleared Canadian customs with destination as indicated. [2] Includes uranium in concentrates. [3] For years 1975-76, uranium almost entirely destined for transshipment, primarily to western Europe and Japan, following conversion and enrichment; for subsequent years, figures represent a mixture of sales to U.S. and others, primarily in western Europe and Japan.
- Nil.

TABLE 6B. EXPORTS[1] OF RADIOACTIVE ELEMENTS[2] AND ISOTOPES FROM CANADA, 1975-80

	U.S.[3]	U.S.S.R.[4]	U.K.	West Germany	Japan	Argentina	France	Belgium Luxembourg	Finland	South Korea	Other	Total
					($000)							
1975	69,596	6,295	1,109	304	787	119	227	-	-	-	3,937	82,374
1976	151,427	24,471	3,786	288	1,068	84	375	-	-	-	4,198	185,697
1977	151,869	6,133	356	384	288	287	685	75	10	-	1,078	161,165
1978	269,903	101,619	38,602	6,918	1,017	12,177	19,046	23	10	-	1,668	450,983
1979	293,577	170,500	5,147	26,159	1,101	94,038	1,762	221	5,493	87	3,992	602,077
1980	199,001	77,235	2,104	20,406	1,911	27,766	144,013	4,847	6,408	137,002	4,686	625,379

Source: Statistics Canada.

[1] Material that cleared Canadian customs with destination as indicated. [2] Includes uranium hexafluoride (UF_6) and radioisotopes for medical and industrial purposes. [3] For years 1975-76, UF_6 component destined for transshipment, primarily to western Europe and Japan, following enrichment; for subsequent years, figures would also include UF_6 sales to the U.S. market. [4] UF_6 component destined entirely for transshipment to western Europe, following enrichment.
- Nil.

NUCLEAR POWER DEVELOPMENTS

As of the end of 1980 it was estimated that 253 nuclear power reactors, with a combined generating capacity of some 136 000 electrical megawatts (MWe), were in operation around the world, and that these reactors generated 8 per cent of the world's total electricity. In Canada, 10 CANDU reactors with an aggregate net output capacity of 5 270 MWe were operating at year-end and another 14 reactors with an aggregate capacity of some 9 879 MWe were either under construction or committed (Table 7).

Of the total electrical energy generated by Ontario Hydro in 1980, hydro-electric sources accounted for some 35 per cent, nuclear-electric units for some 34 per cent, and gas or coal-fired plants for some 30 per cent. As significant quantities of the non-nuclear generated energy were exported, fully 39 per cent of the electricity actually consumed in Ontario during 1980 was generated by nuclear means.

To the end of 1980, six of Ontario Hydro's eight operating CANDU reactors were among the top performers in terms of lifetime capacity factor[1], out of the 115 nuclear power reactors over 500 MWe in service around the world[2] (Table 8).

For two weeks in May, the four units of Ontario Hydro's Pickering "A" Generating Station, just east of Toronto, were shut down to allow for inspection of the vacuum building. The work, a prerequisite to the continued increase in capacity of the adjacent Pickering "B" station, showed the structure to be in excellent condition.

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[1] Lifetime capacity factor is the ratio of electricity produced, from the in-service date of the reactor, relative to that which could have been produced had the reactor operated at its theoretical maximum.

[2] "World" excludes the USSR, Eastern Europe and the People's Republic of China.

TABLE 7. NUCLEAR POWER PLANTS IN CANADA, DECEMBER 1980

Reactors	Owner	Net Output (MWe)	In-Service Dates
Operating			
Nuclear Power Demonstration	Atomic Energy of Canada Limited	22	1962
Douglas Point	Atomic Energy of Canada Limited	208	1968
Pickering 1 to 4	Ontario Hydro	2 056	1971-73
Bruce 1 to 4	Ontario Hydro	2 984	1977-79
Sub-total		5 270	
Under Construction or Committed			
Point Lepreau	New Brunswick Electric Power Commission	630	1982
Gentilly 2	Hydro-Québec	637	1983
Pickering 5 to 8	Ontario Hydro	2 064	1982-84
Bruce 5 to 8	Ontario Hydro	3 024	1983-87
Darlington 1 to 4	Ontario Hydro	3 524	1988-91
Sub-total		9 879	
Grand Total		15 149	

Source: **Uranium in Canada: 1979 Assessment of Supply and Requirements**; Report EP 80-3, Energy, Mines and Resources Canada, September 1980.

At the Bruce Nuclear Power Development on the east short of Lake Huron near Kincardine, Ontario Hydro's Bruce "A" Generating Station remained restricted to 88 per cent of thermal capacity pending the completion of safety studies by Ontario Hydro; construction of the Bruce "B" station proceeded on schedule.

In October, the Douglas Point CANDU prototype, also in the Bruce Nuclear Power Development, was returned to service at 70 per cent power capacity pending approval for full power operations by the Atomic Energy Control Board (AECB). The plant was shut down in early February for routine maintenance work, tests and modifications to its emergency core cooling system as required by AECB.

Construction schedules for the Darlington "A" Generating Station, near Bowmanville, were extended by Ontario Hydro; completion dates for the four units are expected to be November 1988, August 1989, November 1990 and August 1991.

Near Becancour at Hydro-Québec's Gentilly 2 Station (a conventional CANDU-Pressurized Heavy Water Reactor), on-site replacement of the steam-generator tubes and repair of the generators continued through 1980; completion of this work is scheduled for early 1981. Repairs and the decision to modify the service-water system to make it a closed circuit, were expected to delay the commercial start-up of the plant until November 1983. The adjacent Gentilly 1 Station (a CANDU-Boiling Light Water prototype), owned by Atomic Energy of Canada Limited (AECL), did not operate in 1980 but was kept on a care-and-maintenance basis.

TABLE 8. WORLD POWER REACTOR LIFETIME PERFORMANCE (as of December 1980)

Unit/Country		Rank	Capacity Factor[1]
Bruce 3 -	Canada	1	82.6
Stade 1 -	W.Germany	2	82.5
Pickering 2 -	Canada	3	81.5
Pickering 1 -	Canada	4	79.5
Pickering 4 -	Canada	5	78.1
Point Beach 2 -	U.S.	6	78.0
Bruce 4 -	Canada	7	77.6
Prairie Is. -	U.S.	8	76.9
Pickering 3 -	Canada	9	76.1
Calvert Cliffs 2 -	U.S.	10	76.0

Source: Energy, Mines and Resources Canada.

[1] Lifetime capacity factor is the ratio of electricity produced, from the in-service date of the reactor, relative to that which could have been produced had the reactor operated at its theoretical maximum.

TABLE 9. PROJECTION OF WORLD[1] NUCLEAR POWER GROWTH

Year	Low Case	High Case
	(net gigawatts)	
1980	144	159
1985	245	274
1990	373	462
1995	550	770
2000	850	1 200
2005	1 100	1 650
2010	1 300	2 150
2015	1 450	2 700
2020	1 650	3 350
2025	1 800	3 900

Source: **Fuel and Heavy Water Availability**, Report of Working Group 1 of INFCE (Vol. 1); IAEA, Vienna, March 1980.

[1] "World" excludes the USSR, Eastern Europe and the People's Republic of China.

At the Point Lepreau Nuclear Generating Station, 40 km southwest of Saint John, New Brunswick, the replacement of faulty steam-generator tubing progressed on schedule as construction of the circulating cooling water pumphouse neared completion; Point Lepreau will be the first CANDU in Canada cooled by seawater. The New Brunswick Electric Power Commission, owner of the reactor, expected commercial operation at Point Lepreau in 1982.

INTERNATIONAL HIGHLIGHTS

Conclusions to a major study on the long-term growth of nuclear power, which had been carried out within the framework of the International Nuclear Fuel Cycle Evaluation (INFCE), were released in early 1980[1].

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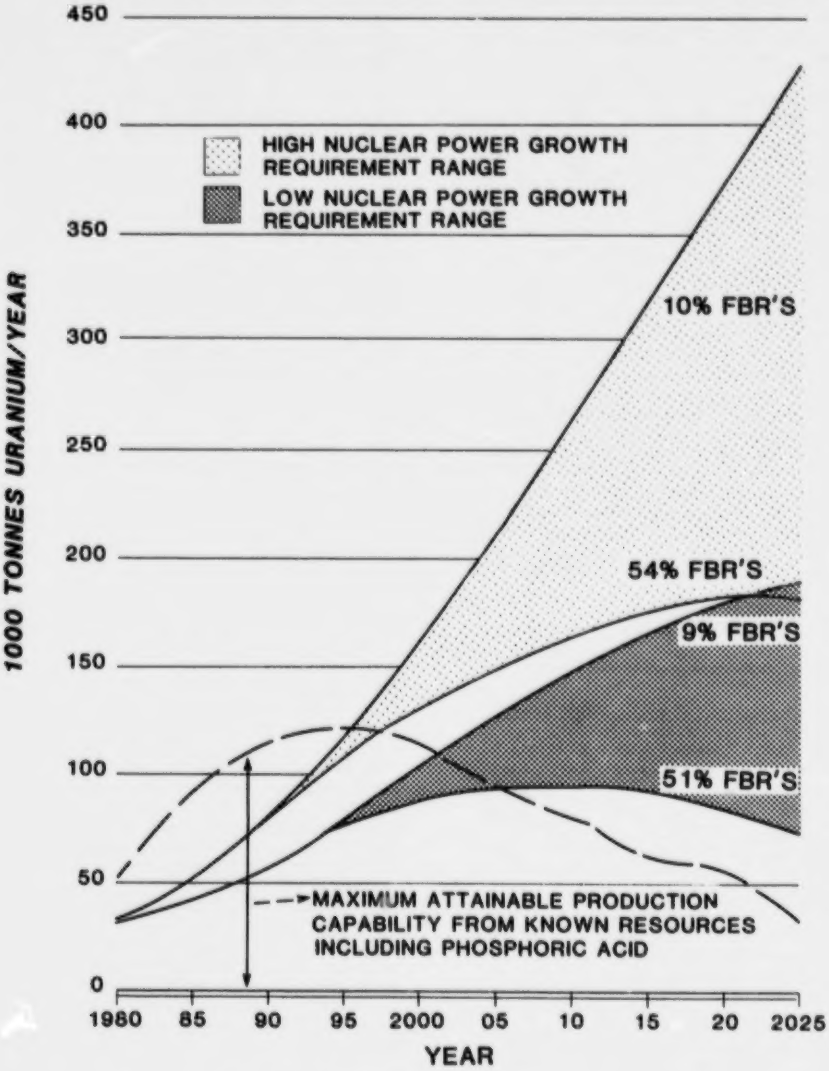
[1] **Fuel and Heavy Water Availability**, Report of Working Group 1 of INFCE (Vol. 1), published by the IAEA, Vienna, March 1980.

LONG TERM OUTLOOK
WORLD URANIUM SUPPLY AND REQUIREMENTS



Source: INFCE WORKING GROUP ONE

Sixty-six nations and five international agencies participated in the study over a two-year period, so that the results represented a fair consensus of the positions of national governments.

Rather than trying to predict the most probable growth pattern of nuclear capacity, INFCE developed a high and low case, with a wide range between them, reflecting the uncertainty of such projections. The INFCE report noted that these were representative projections rather than limiting bounds and that, depending upon decisions and events, both higher and lower capacities were possible. The projections are presented in Table 9.

Over two dozen illustrative fuel requirement scenarios were developed in the INFCE exercise, for both the high and the low nuclear power growth cases, to produce about 50 projections of uranium demand. Within this wide range of projections, those summarized in Figure 3 were considered the most plausible for comparison with projections of supply. The study indicated that world[1] requirements could grow from the current level of about 30 000 t U a year to a level ranging from 130 000 to 160 000 t U a year by the year 2000, and 180 000 to 430 000 t U a year by 2025, assuming a high rate of nuclear power growth and a varying mix of reactor types. Projections that assumed a low rate of nucler power growth with the same reactor strategies resulted in requirement levels ranging from 95 000 to 110 000 t U a year in 2000 and 90 000 to 190 000 t U a year in 2025. The impact on requirements of the introduction of Fast Breeder Reactors (FBR's) in the post-2000 period is evident from Figure 3.

This illustration also shows INFCE's projection of the maximum uranium production level that could be achieved and supported by the world's known resources of uranium, given optimum conditions. It was estimated that a peak production level of about 123 000 t U a year could be reached by 1995, after which production would decline unless new discoveries were forthcoming. The INFCE report cautioned, however, that the achievement of these production levels would require considerable effort as well as a lessening of certain constraints on the industry's expansion.

Comparison of the INFCE supply and requirement projections indicated an apparent surplus of uranium supply capability lasting well into the 1990s. Notwithstanding certain possibilities for modifying this imbalance, these projections indicated that competition for the available market in the short-term would likely be intense. A closer look at the short-term situation (Figure 4) indicated that Canadian producers do not have a monopoly on the available market. The INFCE analysis implied that some of the world's potential new uranium producers might need to defer their development plans and that uranium prices could be expected to decline. Events in 1980 confirmed this view.

In June the sale of Noranda Australia Ltd.'s Koongara uranium deposits to Denison Mines Limited was announced and by September the Australian government's Foreign Investment Review Board had approved the takeover. The Koongara deposits, located some 225 km southeast of Darwin in the middle of Kakadu National Park, Northern Territory, constitute one of Australia's largest uranium prospects. Noranda had indicated development plans for an output capability of some 850 t U per year; the No. 1 and 2 orebodies, amenable to year-round open-pit mining, were estimated to contain about 11 300 t U. Denison's earlier bid to acquire the Australian government's interest in the Ranger uranium project, also in the Northern Territory, was not successful.

At the Ranger project, construction of the ore treatment plant and other facilities was half completed in August and overburden removal had begun; commercial production of some 2 540 t U per year was expected by late-1981. In July, Electrolytic Zinc Company of Australasia Ltd. and Peko-Wallsend Operations Ltd., the major joint-venture partners in the Ranger project, signed contracts to supply 1 731 t U to Indiana & Michigan Electric Co.; delivery over a nine-year period will commence in 1982 at a rate of 192 t U per year.

In September it was announced that the Australian government had negotiated the sale of its share of the Ranger project to Energy Resources of Australia Ltd. (ERA), a consortium of Australian, West German and Japanese companies. In anticipation of the sale being finalized, ERA had previously signed long-term contracts with West Germany and Japan for the sale of some 26 000 t U to be supplied from the Ranger

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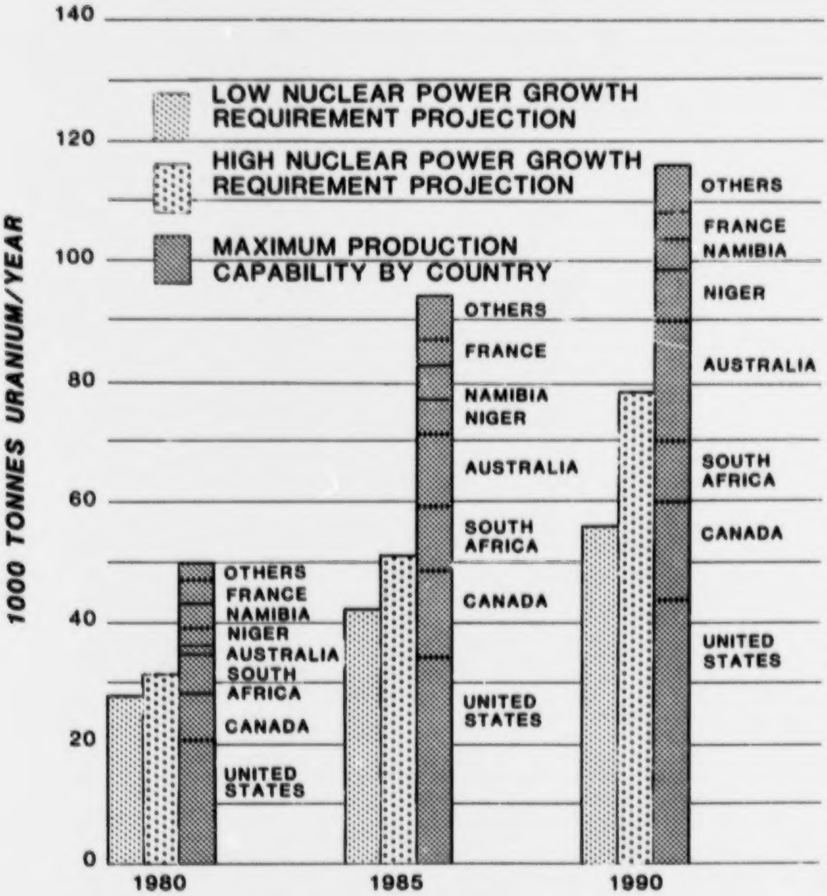
[1] "World" excludes the USSR, Eastern Europe and the People's Republic of China.

SHORT TERM OUTLOOK
WORLD URANIUM SUPPLY AND REQUIREMENTS



Source: INFCE WORKING GROUP ONE

operation over a 15-year period beginning in 1982. The sale, reportedly worth the equivalent of $Cdn 2.5 billion, highlighted Australia's role as a major supplier of uranium to world markets.

With the completion of its mill facility, Queensland Mines Ltd. commenced uranium production in June at its Nabarlek project, also in Australia's Northern Territory. The company estimated that the deposit, previously mined-out and stockpiled, contained at least 12 000 t U; production in 1980 reached some 850 t U.

OUTLOOK

The imbalance between supply and demand that was apparent from the INFCE analysis was augmented by a continued decline in nuclear power expectations in most countries. The decline was nowhere more apparent than in the United States, which accounts for over 40 per cent of the world's currently installed nuclear power capacity and where during 1979 there were no new nuclear plant orders, six cancellations and 69 completion delays. These and similar events in certain other countries were not fully reflected in the INFCE projections presented in Table 9. Indeed, with few exceptions (e.g. France, Britain and Sweden), national projections at year-end were lower than those shown in the table. In a report presented by the Uranium Institute in September 1980, it was noted that the total nuclear power plant capacity committed for 1990 was already some 10 per cent lower than INFCE's low nuclear power growth projection. Similarly, commitments for 1995 were running 35 per cent behind INFCE's low growth projection.

These events contributed to a reduction in short-term uranium market opportunities and to considerable downward pressure on uranium prices. Many companies, particularly in the U.S., reduced their level of production, and there were reports of mine closures and deferrals of uranium development projects; exploration efforts were similarly curtailed. At year-end, there was no evidence for an immediate improvement in the market situation. However, there was a perception that a resurgence in nuclear plant orders in the United States was conceivable as a result of the 1980 Presidential election, and that continuing increases in the price of petroleum could contribute to renewed interest in the nuclear alternative. Although such a resurgence would provide considerable positive impetus to the uranium market it would provide little benefit in terms of short-term sales, since few such plants would be operating before 1990. It seemed likely, therefore, that market opportunities would remain quite limited, at least through the mid-1980s.

Notwithstanding the rather bleak short-term outlook, market prospects in the longer term continued to seem bright. The role of nuclear energy in meeting the world's future energy needs was still expected to be significant, and Canada is well placed in terms of both its existing uranium production capability and its potential for expanding this capability. It follows that, over the longer term, Canada should be in a position to meet its own needs for uranium as well as a significant portion of the needs of its trading partners.

Zinc

M.J. GAUVIN

Balanced supply and demand for zinc metal during the year, coupled with a continuing low level of mine production, worked to keep producer stocks at low operating levels during the year.

The price reacted to these favourable conditions and substantial gains were recorded in all markets by year-end. Production dropped in Canada because of numerous strikes and unforeseen production problems.

MINE OUTPUT AND DEVELOPMENTS IN CANADA

Canadian mine production of zinc in 1980 was 1 058 714 tonnes (t) contained in concentrates, a decrease of 12.1 per cent from the 1 204 401 t produced in 1979. There were 27 mine-mill operations producing these concentrates. Foreign and domestic demand for concentrates remained high and inventories were reduced to below normal working levels.

The utilization of theoretical mill capacity at Canadian operations in 1980 is estimated at 75 per cent, down 8 per cent from 1979. Metal recoveries averaged 83.1 per cent for zinc, almost unchanged from 1979. This recovery reflects the percentage of zinc reporting to the zinc concentrates and bulk concentrates. In 1980 the zinc content of ore milled amounted to 1 266 000 t, of which 1 052 000 t was recovered in the zinc and bulk concentrates. Small quantities of zinc report to other concentrates which are only occasionally recovered by smelters.

During the year, Noranda Mines Limited brought into production its Lyon Lake property in the Sturgeon Lake area of Ontario. The Lyon Lake ore is treated at the Mattabi concentrator. Ore reserves at Lyon Lake are estimated at 2.9 million t averaging 7.48 per cent zinc, 1.44 per cent copper, 0.73 per cent lead and 132 grams of silver per t.

Mining operations ceased late in the year at the Sturgeon Lake area mine of Corporation Falconbridge Copper because of depletion of ore reserves.

Development of a number of zinc mine projects continued during the year. The $53 million expansion at the Number 12 mine of Brunswick Mining and Smelting Corporation Limited in New Brunswick is expected to be completed early in 1981. The expansion will increase Brunswick's No. 12 mine capacity to 10 000 tpd of ore and its capacity to produce zinc and lead in concentrates by 30 000 t and 10 000 t respectively. Noranda is proceeding with the development of its "F" Zone mine in the Sturgeon Lake area of Ontario. It is expected to start up in 1981 producing 11 000 t of zinc in concentrates and 1 000 tpy of lead in concentrates. The ore will be processed by Mattabi Mines.

TABLE 1. CANADA, ZINC PRODUCTION, TRADE AND CONSUMPTION, 1979 AND 1980

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Production				
All forms[1]				
Ontario	289 357	278,881,000	262 594	252,409,000
Northwest Territories	213 323	205,600,000	186 426	179,196,000
New Brunswick	213 841	206,099,000	144 122	138,533,000
Yukon	113 573	109,461,000	76 265	73,307,000
Quebec	78 928	76,070,000	72 750	69,928,000
British Columbia	88 419	85,217,000	62 458	60,036,000
Manitoba	45 549	43,900,000	40 495	38,925,000
Newfoundland	52 446	50,547,000	40 370	38,804,000
Nova Scotia	-	-	4 559	4,382,000
Saskatchewan	4 490	4,328,000	4 536	4,360,000
Total	1 099 926	1,060,103,000	894 575	859,880,000
Mine output[2]	1 204 401		1 058 714	
Refined[3]	580 449		591 565	
Exports				
Zinc blocks, pigs and slabs				
United States	262 002	220,271,000	278 231	259,577,000
United Kingdom	46 989	38,411,000	50 480	41,969,000
Brazil	20 373	16,660,000	15 392	16,571,000
Venezuela	10 491	8,645,000	19 974	15,882,000
India	3 163	2,390,000	14 605	11,650,000
Belgium-Luxembourg	7 029	5,493,000	9 491	7,520,000
Singapore	6 956	5,604,000	8 059	6,347,000
Italy	7 735	6,250,000	5 918	4,777,000
Thailand	4 826	3,806,000	5 683	4,642,000
Nigeria	2 355	1,918,000	5 765	4,530,000
Chile	4 135	3,358,000	5 314	4,034,000
Other countries	53 299	42,715,000	52 773	41,941,000
Total	429 353	355,521,000	471 685	419,440,000
Zinc contained in ores and concentrates				
Belgium-Luxembourg	169 581	76,679,000	113 100	46,308,000
Japan	175 916	64,027,000	124 260	33,988,000
United States	116 096	43,019,000	60 737	20,935,000
West Germany	61 393	20,426,000	46 584	17,862,000
Netherlands	4 124	1,975,000	22 798	10,902,000
Italy	21 926	9,380,000	16 732	6,745,000
United Kingdom	13 853	5,710,000	10 030	5,013,000
Switzerland	-	-	10 835	4,768,000
France	11 600	3,846,000	6 620	2,796,000
Algeria	3 577	1,678,000	3 334	2,313,000
Bulgaria	-	-	3 259	2,191,000
Other countries	20 213	7,196,000	14 314	4,698,000
Total	598 279	233,936,000	432 603	158,519,000
Zinc alloy scrap, dross and ash[4]				
United States	10 295	3,457,000	13 186	5,435,000
Belgium-Luxembourg	321	66,000	2 395	1,469,000
United Kingdom	2 941	989,000	2 894	944,000
Taiwan	111	64,000	542	224,000
West Germany	1 008	174,000	2 073	200,000
Spain	125	72,000	230	111,000
Other countries	642	137,000	877	263,000
Total	15 443	4,959,000	22 197	8,646,000

TABLE 1. (cont'd.)

	1979		1980P	
	(tonnes)	($)	(tonnes)	($)
Zinc dust and granules				
United States	3 477	3,608,000	3 390	3,280,000
Ecuador	-	-	135	117,000
Venezuela	125	150,000	32	45,000
Greece	-	-	49	38,000
Other countries	40	17,000	35	46,000
Total	3 642	3,775,000	3 641	3,526,000
Zinc fabricated material, nes				
United States	1 474	2,316,000	3 250	4,582,000
Brazil	-	-	192	169,000
Belgium-Luxembourg	-	-	177	153,000
West Germany	14	38,000	24	95,000
Costa Rica	26	25,000	40	42,000
Singapore	151	116,000	-	-
New Zealand	124	107,000	-	-
Other countries	148	178,000	38	94,000
Total	1 937	2,780,000	3 721	5,135,000
Imports				
In ores, concentrates and scrap	9 867	5,646,000	59 544	26,167,000
Dust and granules	304	401,000	234	319,000
Slabs, blocks, pigs and anodes	2 573	2,501,000	724	711,000
Bars, rods, plates, strip and sheet	468	843,000	390	703,000
Zinc oxide	1 717	1,558,000	1 526	1,283,000
Zinc sulphate	1 934	826,000	1 322	608,000
Zinc fabricated materials, nes	879	2,253,000	896	2,440,000
Total	17 742	14,028,000	64 636	32,231,000

	1979^r			1980P		
	Primary	Secondary	Total	Primary	Secondary	Total
			(tonnes)			
Consumption[5]						
Zinc used for, or in the manufacture of:						
Copper alloys (brass, bronze, etc.)	11 587					
Galvanizing: electro	1 340	255	87 603	..	..	..
hot dip	74 421					
Zinc die-cast alloy	16 540	X	X			
Other products (including rolled and ribbon zinc, zinc oxide)	23 692	X	X			
Total	127 580	3 737	131 317	..	..	..
Consumer stocks, year-end	13 139	912	14 041			

Sources: Energy, Mines and Resources Canada; Statistics Canada.

[1] New refined zinc produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable zinc in ores and concentrates shipped for export. [2] Zinc content of ores and concentrates produced. [3] Refined zinc produced from domestic and imported ores. [4] Gross weight. [5] Consumer survey does not represent 100 per cent of Canadian consumption and is therefore consistently less than apparent consumption.
P Preliminary; ^{r} Revised; .. Not available; - Nil; nes Not elsewhere specified; X Confidential.

TABLE 2. CANADA, ZINC MINE OUTPUT, 1979 AND 1980

	1979	1980
	(tonnes)	
Newfoundland	54 155	47 061
Nova Scotia	1 274	4 807
New Brunswick	251 676	171 595
Quebec	93 034	78 752
Ontario	300 631	302 977
Manitoba-Saskatchewan	65 080	57 416
British Columbia	91 261	71 087
Yukon Territory	119 936	98 355
Northwest Territories	227 354	226 664
Total	1 204 401	1 058 714

Source: Energy, Mines and Resources Canada.

Noranda has also started work to bring its Goldstream, British Columbia copper-zinc property into production late in 1982. Zinc production is expected to be 5 000 tpy of zinc in concentrate. Another Noranda project is the former West Macdonald mine near Noranda, now owned by Les Mines Gallen Limitée which is 50 per cent owned by Noranda. The mine will be brought into production in 1981 as an open-pit and will produce 1 000 to 1 500 tpd of ore for treatment at Noranda's Horne Division concentrator. Zinc output is expected to be about 19 000 tpy. Ore reserves are estimated at 1.8 million t averaging 5.4 per cent zinc and recoverable values in precious metals.

Cyprus Anvil Mining Corporation has decided to proceed with the development, of the Vangorda and Grum deposits which it acquired in 1978. Cyprus plans to bring the Vangorda into production in 1985 and the Grum in 1988. The new ore will be blended with ore from the existing Faro mine and thus extend the Faro camp's life, possibly into the next century.

Cominco Ltd., the operator for Arvik Mines Ltd., has started development of the Polaris zinc-lead mine on Little Cornwallis Island in the Canadian high arctic. Only 133 km from the magnetic north pole, Polaris will be the most northerly mine in the world. The mine is expected to cost $150 million and its 2 000 tpd mill is expected to produce 100 000 t of zinc in concentrates and 30 000 t of lead in concentrates when production starts in 1982. Ore reserves are estimated at 25.4 million t grading 14.1 per cent zinc and 4.3 per cent lead.

Hudson Bay Mining and Smelting Co., Limited has entered into a joint venture with Gränges Exploration AB Sweden and the provincial crown corporation, Manitoba Mineral Resources Ltd., to develop a copper-zinc

TABLE 3. CANADA, ZINC PRODUCTION, EXPORTS AND DOMESTIC SHIPMENTS, 1970, 1975-80

	Production		Exports			Producers'
	All Forms[1]	Refined[2]	In Ores and Concentrates	Refined	Total	Domestic Shipments
			(tonnes)			
1970	1 135 714	417 906	809 248	318 834	1 128 082	106 405
1975	1 055 151	426 902	705 088	247 474	952 562	149 214
1976	982 057	472 316	653 737	352 072	1 005 809	133 561
1977	1 070 515	494 938	598 452	295 358	893 810	120 727^r
1978	1 066 902	495 243	689 336	439 261	1 128 597	144 740
1979	1 099 926	580 449	598 279	429 353	1 027 632	153 744
1980P	894 575	591 565	432 603	471 685	904 288	132 543

Source: Energy, Mines and Resources Canada; Statistics Canada.

[1] New refined zinc produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable zinc in ores and concentrates shipped for export. [2] Refined zinc produced from domestic and imported ores.
P Preliminary; ^{r} Revised.

TABLE 4. CANADA, PRODUCERS' DOMESTIC SHIPMENTS OF REFINED ZINC, 1978-80

	1978	1979	1980P
		(tonnes)	
1st Quarter	42 492	42 951	37 858
2nd Quarter	33 439	40 015	30 295
3rd Quarter	30 806	30 528	30 510
4th Quarter	38 003	40 250	33 880
Total	144 740	153 744	132 543

Sources: Energy, Mines and Resources Canada; Statistics Canada.
P Preliminary.

orebody at Trout Lake, near Flin Flon, Manitoba. The ore will be treated at the Hudson Bay concentrator in Flin Flon. The mine is expected to come into production in 1982 and produce 11 000 tpy of zinc in concentrates.

Other zinc projects under active consideration are:

- the Howard's Pass zinc-lead deposit in the Yukon Territory, held by Placer Development Limited and United States Steel Corporation, with potential output of 200 000 tpy of zinc in the mid- to late-1980s.
- the Great Slave Reef zinc-lead deposit near Pine Point in the Northwest Territories, held by Western Mines Limited, Philipp Brothers (Canada) Ltd. and Du Pont Canada Inc. with potential output of 45 000 tpy of zinc in 1985-86.
- the Kutcho Creek copper-zinc deposit near Dease Lake, British Columbia, held by Esso Minerals Canada and Sumac Mines Ltd., with potential output of 25 000 tpy of zinc in the mid-1980s.
- the P.D. copper-zinc deposit in Quebec, held by Noranda Mines Limited, with potential output of 11 000 tpy of zinc in the early 1980s.
- the Magusi copper-zinc deposit in Quebec, held by Noranda Mines Limited, with potential output of 11 000 tpy of zinc in the mid-1980s.
- the Tom zinc-lead deposit of Hudson Bay Mining and Smelting Co., Limited at MacMillian Pass in the Yukon, with potential output of 90 000 tpy of zinc in the in the mid- to late-1980s.

The total potential output represented by these projects either under development or being seriously considered, is approximately 568 000 tpy of additional zinc mine capacity in Canada.

METAL OUTPUT AND DEVELOPMENT IN CANADA

Refined zinc metal production in Canada in 1980 was 591 565 t compared with 580 449 t in 1979. Canada is the western world's second-largest zinc metal producer following Japan, which produced an estimated 739 000 t in 1980.

The three largest zinc metal refineries are in the process of adding incremental increases to their capacity. Cominco Ltd. is continuing with its program of expanding the capacity of its zinc plant at Trail, British Columbia by 25 000 tpy. This program includes a new electrolytic and melting facility and a new zinc pressure-leaching plant. The latter facility will be the first commercial-scale zinc pressure-leaching plant using a process developed jointly by Cominco and Sherritt Gordon Mines Limited and will allow the company to produce elemental sulphur instead of sulphur dioxide gas. Canadian Electrolytic Zinc Limited (CEZ) will add 9 000 t to its capacity by 1984 and Texasgulf Canada Ltd. will expand its facilities at Hoyle, Ontario by 18 000 t in 1983.

In February 1979, Brunswick Mining and Smelting Corporation Limited began detailed work on process selection and engineering for a 100 000 tpy electrolytic zinc refinery at Belledune, New Brunswick. The program, scheduled for completion early in 1981, is being financed by the company, the federal government and the province.

Domestic zinc consumption as measured by producers' shipments dropped to an estimated 132 000 t from 153 744 t in 1979. The steel sector is Canada's largest consumer of zinc, accounting for about 50 per cent of domestic usage; galvanized steel, sheet and strip is the principal outlet. Stelco Inc. and Dofasco Inc. have installed capacity to produce about 910 000 tpy of galvanized sheet

TABLE 5. PRINCIPAL ZINC MINES IN CANADA, 1980 AND (1979)

Company and Location	Daily Mill Capacity	Zinc	Lead	Copper	Silver	Ore Produced	Zinc Concentrates Produced	Zinc Concentrates Zinc Grade	Zinc Content of all Concentrates	Destination of Zinc Concentrate
	(tonnes ore)	(%)	(%)	(%)	(grams/ tonne)	(tonnes)	(tonnes)	(%)	(tonnes)	
Newfoundland										
ASARCO Incorporated	1 100	9.38	5.42	0.85	102.5	75 297	10 002	55.05	6 646	6
Buchans	(1 100)	(11.64)	(6.51)	(1.04)	(109.7)	(113 398)	(18 527)	(56.40)	(12 413)	(6)
Newfoundland Zinc Mines	1 500	8.19	-	-	-	518 125	67 536	61.60	41 602	3,6,8
Limited,	(1 500)	(8.56)	(-)	(-)	(-)	(523 598)	(71 519)	(61.38)	(43 898)	(3,6,12)
Daniel's Harbour										
Nova Scotia										
Esso Resources Canada Limited	1 500	2.04	1.43	-	-	261 942	7 808	61.66	4 991	6
Gays River	(1 500)	(4.50)	(2.50)	(-)	(-)	(45 359)	(3 016)	(62.00)	(1 877)	(-)
New Brunswick										
Brunswick Mining and Smelting	9 050	8.80	3.56	0.31	97.4	1 848 036	262 206	49.53	139 863	3,6,7,8, 9,10,11,12
Corporation Limited										
Bathurst	(9 050)	(8.93)	(3.61)	(0.31)	(95.0)	(2 971 516)	(418 968)	(49.43)	(222 588)	(3,7,8,9, 11,12)
Heath Steele Mines Limited	3 600	4.34	1.45	0.84	55.2	1 252 406	86 346	48.33	44 872	3,6,8,9,12
Newcastle	(3 600)	(4.55)	(1.53)	(0.91)	(55.2)	(1 172 737)	(84 508)	(48.72)	(43 925)	(6,8,9,12)
Quebec										
Corporation Falconbridge	1 400	2.19	-	2.70	28.8	475 464	13 820	52.14	8 559	3
Copper	(1 400)	(4.90)	(-)	(3.60)	(48.7)	(419 827)	(31 822)	(52.18)	(19 151)	(3)
Lake Dufault Division										
Noranda										
Lemoine Mines Limited	300	10.00	-	4.71	88.8	104 326	14 756	52.41	9 217	12
Lemoine Mine	(300)	(11.61)	(-)	(5.07)	(92.9)	(108 267)	(18 723)	(52.30)	(11 477)	(12)
Chibougamau										
Louvem Mining Company Inc.	900	3.89	0.11	0.15	30.4	224 530	13 806	54.42	7 945	2,6
Val d'Or	(900)	(4.51)	(0.55)	(0.04)	(137.8)	(72 261)	(4 793)	(56.70)	(2 906)	(6)
Noranda Mines Limited	4 000	4.81	-	0.77	21.4	1 328 360	108 683	52.39	56 939	3
Mattagami Division	(4 000)	(5.37)	(-)	(0.73)	(26.9)	(1 329 428)	(123 228)	(52.04)	(64 128)	(3,6)
Mattagami										

Ontario										
Corporation Falconbridge Copper Sturgeon Lake Joint Venture Sturgeon Lake	1 100 (1 100)	5.89 (8.70)	1.05 (1.23)	1.46 (2.17)	131.7 (169.7)	371 623 (373 953)	33 421 (43 677)	52.30 (53.12)	19 206 (26 650)	1,3,12 (3,6)
Mattabi Mines Limited Sturgeon Lake	2 700 (2 700)	7.24 (6.91)	0.87 (0.77)	0.44 (0.55)	106.6 (97.7)	846 940 (945 015)	102 466 (108 617)	52.33 (52.89)	55 743 (59 511)	1,2,3,12 (1,2,3,12)
Noranda Mines Limited Geco Division Manitouwadge	4 550 (4 550)	3.32 (3.24)	0.14 (0.11)	1.47 (1.82)	60.7 (59.0)	1 358 317 (1 475 841)	73 569 (75 042)	51.54 (50.13)	41 442 (44 023)	1,3 (3)
Selco Mining Corporation Limited, South Bay Division Uchi Lake	450 (450)	8.79 (10.75)	- (-)	1.48 (1.44)	65.5 (63.8)	117 291 (132 923)	17 178 (23 332)	52.73 (52.97)	9 274 (12 595)	6 (6)
Texasgulf Canada Ltd. Kidd Creek	12 250 (9 050)	5.78 (5.47)	0.18 (0.15)	1.83 (1.95)	86.4 (76.0)	3 899 615 (3 680 858)	351 615 (310 326)	52.62 (53.42)	198 204 (178 505)	3,5,6,12 (5,6)
Manitoba and Saskatchewan										
Hudson Bay Mining and Smelting Co., Limited, Flin Flon	7 250 (7 250)	2.11 (2.36)	0.15 (0.17)	1.67 (1.64)	19.8 (22.8)	945 379 (870 792)	19 383 (23 694)	44.36 (45.97)	14 263 (15 027)	2 (2)
Snow Lake	3 450 (3 450)	3.23 (4.03)	0.23 (0.14)	2.65 (2.72)	16.7 (12.3)	756 283 (830 047)	38 611 (39 462)	51.73 (51.91)	21 027 (22 308)	2 (2)
Sherritt Gordon Mines Limited, Fox mine Lynn Lake	2 700 (2 700)	1.56 (1.82)	- (-)	1.40 (1.19)	6.5 (4.7)	784 011 (772 500)	16 302 (20 583)	50.50 (50.90)	9 602 (12 066)	2 (2)
Ruttan mine Ruttan Lake	9 050 (9 050)	1.02 (1.17)	- (-)	1.36 (1.39)	6.5 (5.6)	2 311 444 (2 094 159)	27 163 (32 905)	51.33 (51.44)	16 577 (18 661)	2 (2,6)
British Columbia										
Cominco Ltd. Sullivan mine Kimberley	9 050 (9 050)	2.73 (3.73)	3.85 (5.33)	- (-)	44.6 (63.8)	2 132 416 (2 047 726)	95 449 (129 443)	49.29 (49.37)	52 103 (70 794)	1 (1)
Dickenson Mines Limited Silmonac mine Sandon	100 (100)	3.03 (4.51)	3.21 (4.89)	- (-)	295.9 (478.6)	28 223 (19 625)	1 233 (1 323)	50.60 (51.05)	738 (810)	6 (6)
Northair Mines Ltd. Brandywine area	250 (250)	2.15 (1.50)	1.38 (0.91)	0.50 (0.50)	32.3 (26.3)	71 478 (91 587)	2 224 (1 643)	50.49 (51.34)	1 361 (1 124)	1 (1)

TABLE 5. (cont'd.)

Company and Location	Daily Mill Capacity (tonnes ore)	Zinc (%)	Lead (%)	Copper (%)	Silver (grams/ tonne)	Ore Produced (tonnes)	Zinc Concentrates		Zinc Content of all Concentrates (tonnes)	Destination of Zinc Concentrate
							Produced (tonnes)	Zinc Grade (%)		
British Columbia (continued)										
Teck Corporation Beaverdell mine Beaverdell	100 (100)	0.56 (0.63)	0.23 (0.28)	- (-)	290.7 (320.2)	38 550 (33 662)	359 (343)	27.20 (29.40)	126 (133)	1 (1)
Western Mines Limited Lynx and Myra Falls	900 (900)	7.58 (8.45)	1.23 (1.37)	1.22 (1.32)	124.1 (131.3)	278 244 (266 877)	32 468 (35 834)	53.59 (51.96)	19 805 (20 975)	6,12 (6,12)
Yukon Territory										
Cyprus Anvil Mining Corporation Faro	9 050 (9 050)	4.68 (5.28)	3.12 (3.26)	- (0.20)	47.0 (25.0)	2 825 150 (2 823 031)	209 362 (250 701)	47.12 (47.85)	108 998 (126 901)	7,8,12 (7,8,12)
United Keno Hill Mines Limited Elsa	450 (450)	0.79 (-)	3.39 (3.00)	- (-)	787.2 (818.4)	79 636 (112 783)	- (-)	- (-)	233 (-)	- (-)
Northwest Territories										
Pine Point Mines Limited Pine Point	10 000 (10 000)	5.49 (5.48)	1.96 (1.91)	- (-)	- (-)	3 289 329 (2 985 536)	285 366 (261 161)	57.71 (57.25)	166 457 (151 029)	1,2,8 (1,2,6,8,12)
Nanisivik Mines Ltd. Baffin Island	2 200 (2 200)	14.28 (12.92)	2.37 (1.39)	- (-)	86.3 (66.2)	435 147 (615 459)	104 822 (133 353)	57.00 (57.22)	59 882 (76 498)	6,8,9,12 (6,8,9)

Sources: Company reports in response to survey by Energy, Mines and Resources Canada.
Destination of concentrates: (1) Trail; (2) Flin Flon; (3) Valleyfield; (4) Belledune; (5) Timmins; (6) United States; (7) Japan; (8) Germany; (9) Belgium; (10) France; (11) Britain; (12) Unspecified, and other countries.
(-) Nil.

TABLE 6. CANADA, PRODUCERS' ZINC ORE RESERVES AT DECEMBER 31, 1980

Company and Province	Zinc-Bearing Ore Reserves (000 tonnes)	Per Cent Zinc (%)	Zinc in Ore (000 tonnes)
Newfoundland			
ASARCO Incorporated (Buchans)	341.1	11.24	38.3
Newfoundland Zinc Mines Limited	1 509.6	8.3	125.3
	1 850.7	8.84	163.6
Nova Scotia			
Esso Minerals Canada (Gays River)[1]	4 239.3	3.31	140.3
Yava Mines Limited	870.9	5.46	47.6
	5 100.2	3.68	187.9
New Brunswick			
Brunswick Mining and Smelting Corporation Limited	99 915.0	8.28	8 273.0
Heath Steele Mines Limited	29 120.9	4.39	1 278.4
	129 035.9	7.4	9 551.4
Quebec			
Corporation Falconbridge Copper (Corbet)	2 694.3	2.05	55.2
Corporation Falconbridge Copper (Millenbach)	-	-	-
Les Mines Gallen Limitée (West MacDonald)[1]	1 642.0	5.40	88.7
Noranda Mines Limited (Orchan)	106.1	5.47	5.8
Noranda Mines Limited (Norita and Radiore No. 2)	2 851.3	3.45	98.4
Noranda Mines Limited (Mattagami)	5 465.8	6.80	371.7
	12 759.5	4.86	619.8
Ontario			
Corporation Falconbridge Copper (Sturgeon)		- Nil -	
Mattabi Mines Limited	4 885.2	7.31	357.1
Noranda Mines Limited (Geco)	18 934.5	3.72	704.3
Noranda Mines Limited (Lyon Lake)[1]	2 874.9	7.48	215.0
Noranda Mines Limited (F Group)[1]	562.5	8.22	46.2
Texasgulf Canada Ltd.	97 160.5	5.06	4 916.3
	124 417.6	5.01	6 238.9
Manitoba and Saskatchewan			
Hudson Bay Mining and Smelting Co., Limited	15 486.1	2.80	433.6
Sherritt Gordon Mines Limited (Ruttan)	22 708.8	1.18	268.0
Sherritt Gordon Mines Limited (Fox)	4 908.8	2.21	108.5
	43 103.8	1.88	810.1
British Columbia			
Cominco Ltd. (Sullivan)	48 081.3	6.00	2 884.9
Dickenson Mines Limited (Silvana Division)	136.1	4.00	5.4
Northair Mines Ltd.	79.2	3.12	2.5
Teck Corporation (Beaverdell)	30.0	1.00	0.3
Western Mines Limited (Buttle Lake)	1 037.8	8.00	83.0
	49 364.4	6.03	2 976.1
Yukon Territory			
Cyprus Anvil Mining Corporation (Faro)	58 000.0	4.20	2 784.0
United Keno Hill Mines Limited	108.7	1.37	1.5
	58 108.7	4.79	2 785.5
Northwest Territories			
Arvik Mines Ltd. (Polaris and Eclipse)[1]	23 042.7	14.10	3 249.0
Nanisivik Mines Ltd.	3 250.0	12.00	390.0
Pine Point Mines Limited	37 195.0	5.30	1 971.3
	63 487.7	8.91	5 655.3
National Total	487 228.5	5.95	28 988.6

[1] Committed but not in production at January 1, 1980.

TABLE 7. CANADA'S ZINC-BEARING DEPOSITS CONSIDERED MOST PROMISING FOR FUTURE PRODUCTION

Company and Province	Deposit Name	Indicated Tonnage	Per Cent Zinc	Zinc Content
		(000 t)		(000 t)
New Brunswick				
Placer Development Limited and	Restigouche	2 721.6	6.00	163.3
Gowganda Silver Mines Limited	Murray Brook	21 479.8	1.95	418.9
Caribou-Chaleur Bay Mines Ltd.	Caribou	44 815.4	4.48	2 007.7
Cominco Ltd.	Stratmat 61	2 041.2	6.29	128.4
Key Anacon Mines Limited	Key Anacon	851.9	5.98	50.9
	Key Anacon	917.2	5.78	53.0
Texasgulf Inc. and Bay Copper Mines Limited	Halfmile Lake	6 168.9	6.80	419.5
		78 996.0	4.10	3 241.7
Quebec				
Louvem Mining Company Inc.	Louvicourt	726.6	6.38	46.4
Noranda Mines Limited	Magusi	1 378.9	4.80	66.2
	P.D. Division	1 401.6	4.50	63.1
Selco Mining Corporation	Detour A1	32 114.7	2.30	738.6
Limited	Detour B	3 447.3	0.50	17.2
Muscocho Explorations Limited	Montauban	691.2	3.46	23.9
Ontario				
Giant Yellowknife Mines Limited	Low Pyrite	4 008.4	3.97	159.1
Ettington and Vermillion Mines	High Pyrite	8 199.5	3.82	313.2
		39 760.3	2.40	955.4
Manitoba				
Dickstone Copper Mines Limited		304.4	4.50	13.7
Falconbridge Nickel Mines Limited and Stall Lake Mines Limited	Stall Lake	610.2	2.28	13.9
Hudson Bay Mining and Smelting Co., Limited	Rail Lake	294.8	0.70	2.1
Gränges Exploration AB	Trout Lake	3 175.2	4.30	136.5
Manitoba Mineral Resources Ltd.				
		4 384.6	3.79	166.2
British Columbia				
Imperial Oil Limited	Kutcho Creek	..	3.0	..
Sumitomo Metal Mining Co. Ltd.				
Noranda Mines Limited	Goldstream	3 628.8	2.60	94.3
Yukon Territory				
Hudson Bay Mining and Smelting Co., Limited	Tom	7 842.7	8.40	658.8
Cyprus Anvil Mining Corporation	Grum	26 081.8	6.40	1 669.2
	Swim Lake	4 536.0	5.50	249.5
	Vangorda	8 527.6	4.96	423.0
Placer Development Limited and United States Steel Corporation	Howard's Pass[1]	272 158.2	6.40	17 418.1
Sovereign Metals Corporation	Mel Property	3 628.8	5.20	188.7
		322 775.1	8.15	20 607.3

TABLE 7. (cont'd.)

Company and Province	Deposit Name	Indicated Tonnage	Per Cent Zinc	Zinc Content
		(000 t)		(000 t)
Northwest Territories				
Bathurst Norsemines Ltd.	Cleaver Lake	3 628.8	7.07	256.6
and Cominco Ltd.	Boot Lake	4 536.0	4.97	225.4
	Main A Group	3 628.8	8.50	308.4
Cadillac Explorations Limited	Prairie Creek	1 814.4	15.50	281.2
Texasgulf Canada Ltd.	Isok Lake	11 022.4	13.77	1 517.8
	Hood River 10	453.6	3.50	15.9
	Hood River 41	290.3	3.20	9.3
Western Mines Limited	R-19º	1 270.1	..	..
Du Pont Canada Inc. and	V-46	544.3	..	..
Philipp Brothers (Canada) Ltd.	X-25	3 447.3	9.10	313.7
		30 636.0	10.16	2 928.3
Canada		492 388.7	5.80	28 465.5

Source: R.T. Whillans and D.A. Cranstone, **Canadian Reserves of Copper, Nickel, Lead, Zinc, Molybdenum, Silver and Gold, as of January 1, 1979**; MR 186, Energy, Mines and Resources Canada, 1979.

[1] MR 186 indicates ore reserves at Howard's Pass exceed 272.2 million tonnes with an average grade of 6-12% combined lead-zinc. Data in above table compiled using a lead-to-zinc ratio of about 1.0/2.5 applied to an average grade of 9% combined lead and zinc based upon minimum ore reserves.

.. Not available.

steel; however, in 1981 this will increase by about 420 000 tpy due to the addition of two new lines. When operating at capacity, they should increase domestic consumption of zinc by about 15 per cent.

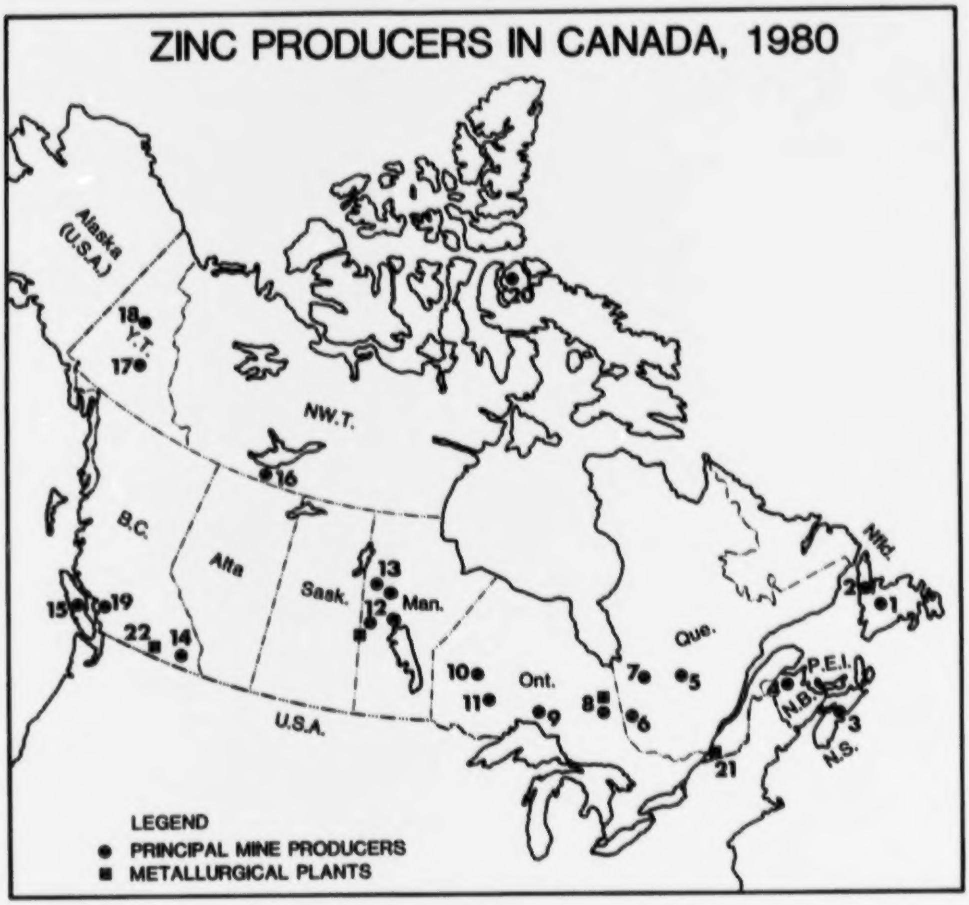
Consumer surveys by Statistics Canada cover less than 80 per cent of zinc consumption in Canada. The most recent survey of zinc consumption (for 1979) indicated that the manufacture of copper alloys consumed 11 587 t of zinc; galvanized steel consumed 75 761 t; zinc diecast alloys consumed 16 540 t; and zinc oxides, rolled zinc etc. consumed 23 692 t; a total of 127 580 t. All sectors that use zinc in Canada are also export-dependent for a significant proportion of the output of their products.

WESTERN WORLD OUTPUT AND DEVELOPMENT FOR ZINC

In 1975-77 a large surplus of zinc products depressed world zinc prices. During 1978 world stocks of zinc metal declined to normal levels and 1979 saw a massive reduction of zinc concentrate stocks. During 1980 there was a relative balance between mine production, metal production and consumption. Prices during the year reflected the level of world economic activity.

There was a modest decline in prices during the first eight months of the year but at the end of August, producers increased prices and revamped their pricing system for zinc products by switching from a prime western base to a high-grade or special high-grade base. This was logical, in that electrolytic high-grade producers have for many years been the dominant force in the industry and the pyrometallurgical prime western producers who once dominated the industry are mostly closed down. Electrolytic producers must add lead to their base product to produce the prime western grade and they are charging more for it rather than less, as under the previous system.

World mine production of zinc in 1980 is estimated at 4 528 000 t compared with 4 597 000 t in 1979. During the year 93 000



ZINC PRODUCERS IN CANADA, 1980

Alaska (U.S.A.)
Y.T.
N.W.T.
B.C.
Alta
Sask.
Man.
Ont.
Que.
Nfld.
P.E.I.
N.B.
N.S.
U.S.A.
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
LEGEND
● PRINCIPAL MINE PRODUCERS
■ METALLURGICAL PLANTS

Principal Producers
(numbers refer to numbers on map above)

1. ASARCO Incorporated (Buchans Unit)
2. Newfoundland Zinc Mines Limited
3. Esso Resources Canada Limited
   (Gays River)
4. Brunswick Mining and Smelting
   Corporation Limited
   Heath Steele Mines Limited
5. Lemoine Mines Limited
6. Corporation Falconbridge Copper
   Lake Dufault Division
   Louvem Mining Company Inc.
7. Mattagami Lake Mines Limited
   Noranda Mines Limited (Orchan mine)
8. Texasgulf Canada Ltd.
9. Noranda Mines Limited (Geco Division)
10. Selco Mining Corporation Limited
11. Mattabi Mines Limited
    Noranda Mines Limited (Lyon Lake)
12. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake, Osborne Lake, Stall Lake, Ghost Lake, Anderson Lake, Westarm, Flin Flon, White Lake, Centennial)
13. Sherritt Gordon Mines Limited
    (Fox Lake mine and Ruttan mine)

Producers (cont'd)

14. Cominco Ltd. (Sullivan mine)
    Teck Corporation (Beaverdell mine)
    Dickenson Mines Limited
    (Silmonac mine)
15. Western Mines Limited
16. Pine Point Mines Limited
17. Cyprus Anvil Mining Corporation
18. United Keno Hill Mines Limited
19. Northair Mines Ltd.
20. Nanisivik Mines Ltd.

Metallurgical Plants

8. Texasgulf Canada Ltd., Hoyle
12. Hudson Bay Mining and Smelting Co., Limited, Flin Flon
21. Canadian Electrolytic Zinc Limited, Valleyfield
22. Cominco Ltd., Trail

t of new mine capacity started production, the most significant being the Broken Hill mine at Aggeneys, South Africa, and the Lyon Lake mine in Ontario. Some 255 000 t of new capacity is expected to come on-stream in 1981. The Broken Hill mine of Black Mountain Mineral Development Company Limited in South Africa is expected to produce 90 000 tpy of lead and 18 000 tpy of zinc in concentrates. The mine has reserves of 34.5 million t averaging 6.35 per cent lead and 2.87 per cent zinc. Refined metal production was about 4 471 000 t, down from the 4 706 000 t produced in 1979. Average operating rate in 1980 was about 78 per cent of capacity.

TABLE 8. CANADA, PRIMARY ZINC METAL CAPACITY, 1980

Company and Location	Annual Rated Capacity
	(t of slab zinc)
Canadian Electrolytic Zinc Limited (CEZ) Valleyfield, Quebec	218 000
Texasgulf Canada Ltd. Hoyle, Ontario	108 000
Hudson Bay Mining and Smelting Co., Limited Flin Flon, Manitoba	77 000
Cominco Ltd. Trail, British Columbia	245 000
Canada total	648 000

Source: Energy, Mines and Resources Canada.

New Jersey Zinc Company has closed the vertical retort slab zinc portion of its smelter at Palmerton, Pennsylvania, but will continue to produce other zinc products at the plant. The Palmerton plant was the last vertical retort plant operating in the United States.

St. Joe Minerals Corporation has announced the partial reopening of its Monaca, Pennsylvania zinc smelter that was closed in 1979. The plant will be operated at a rate of 45 000 tpy; full capacity of the plant is 200 000 t. St Joe is opening its Pierrepont zinc mine in northern New York. The ore will be processed at St Joe's nearby Balmat mill, and the Monaca smelter will handle most of the output of the Pierrepont and Balmat mines.

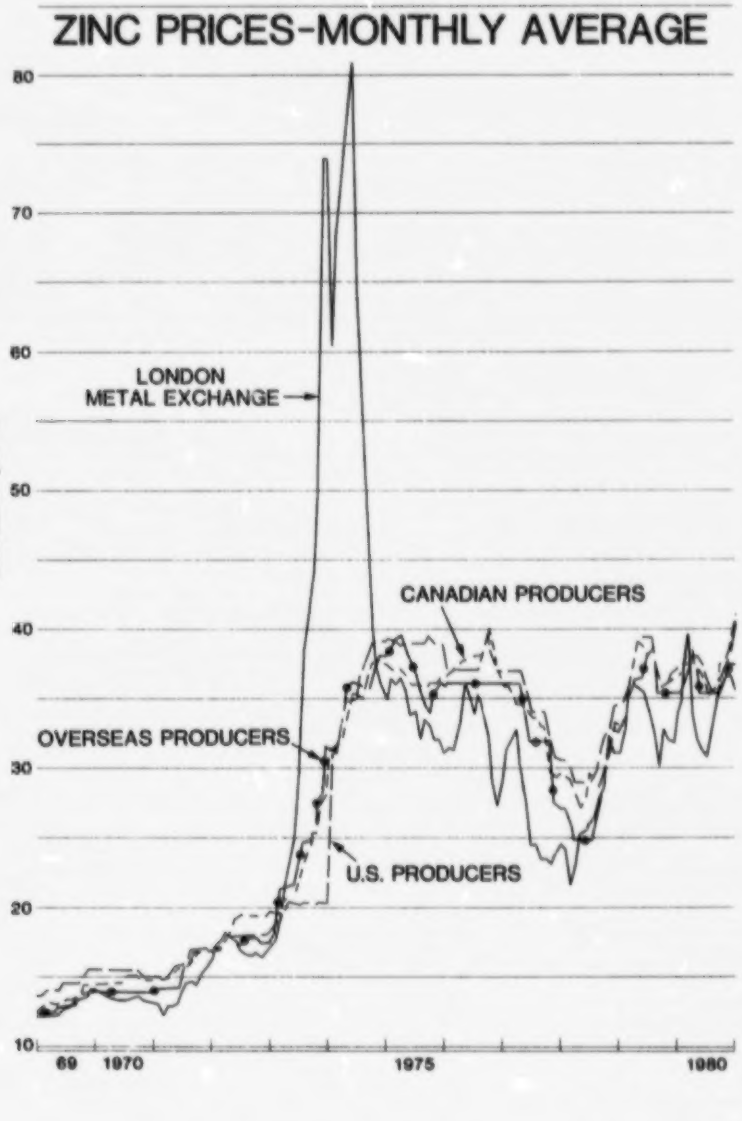
The tight supply of zinc concentrates coupled with poor metal sales have been cited as the reason for a 20 per cent curtailment at the French plant of Cie. Royale Asturienne des Mines. Other European

TABLE 9. WESTERN WORLD PRIMARY ZINC STATISTICS, 1978-81

	1978	1979	1980[p]	1981[e]
	(000 tonnes)			
Mine production (Zn content)	4 676	4 597	4 528	4 578
Metal production	4 293	4 706	4 471	4 593
Metal consumption	4 256[r]	4 607	4 487	4 477

Source: International Lead and Zinc Study Group.

[e] Estimated by Energy, Mines and Resources Canada.
P Preliminary; [r] Revised.



ZINC PRICES-MONTHLY AVERAGE
U.S. cents per lb.
80
70
60
50
40
30
20
10
69
1970
1975
1980
LONDON METAL EXCHANGE
CANADIAN PRODUCERS
OVERSEAS PRODUCERS
U.S. PRODUCERS

TABLE 10. WESTERN WORLD ZINC INDUSTRY, PRODUCTION AND CONSUMPTION, 1980

	Mine Production	Metal Consumption	Metal Production
	(000 t primary zinc)		
Europe (EEC-EFTA)[1]			
Austria	19	27	22
Belgium	-	155	248
Denmark	92	15	-
Finland	58	25	147
France	37	330	253
West Germany	121	406	365
Ireland	223	4	-
Italy	59	236	207
Netherlands	-	45	169
Norway	28	15	79
Portugal	-	17	2
Sweden	167	35	-
Switzerland	-	25	-
United Kingdom	4	181	87
Total	808	1 516	1 579
Europe (Other)			
Greece	27	19	-
Spain	183	105	162
Yugoslavia	95	73	85
Total	305	197	247
Africa			
Algeria	8	12	28
Congo	-	-	-
Morocco	6	3	-
South Africa	115	84	81
Tunisia	8	1	-
Zaire	67	2	44
Zambia	43	1	33
Other	-	53	-
Total	247	156	186
Americas			
Argentina	34	28	28
Bolivia	50	-	-
Brazil	67	138	78
Canada	1 059	133	592
Mexico	238	89	145
Peru	488	23	66
United States	368	879	370
Other	21	63	-
Total	2 325	1 353	1 279
Asia			
India	24	95	44
Japan	238	752	735
South Korea	57	68	81
Turkey	20	12	13
Other	41	222	-
Total	380	1 149	873
Oceania			
Australia	463	100	306
New Zealand	-	16	-
Total	463	116	306
Total Western World	4 528	4 487	4 470

Sources: International Lead and Zinc Study Group; Energy, Mines and Resources Canada.

[1] European Economic Community (Common market) - European Free Trade Association.

zinc producing companies - Société Minière et Métallurgique de Penarroya S.A., Preussag Aktiengesellschaft (AG) and Société des Mines & Fonderies de Zinc de la Vieille-Montagne S.A. and Société de Prayon - have also cut back production. Japanese smelters made further production cutbacks mainly because of electricity charges, which were increased 50 per cent during the year, and the higher cost of imported concentrates.

The French government has set up a new stockpiling agency which plans to spend some $400 million before the end of 1981 for the purchase of non-energy raw materials. While the agency is reported to have purchased considerable quantities of zinc to offset a possible shortage of zinc concentrates in the national industry, no announcement has been made of the amount purchased. The Japanese and United States governments released 22 000 t and 4 000 t of zinc, respectively, during the year from their stockpiles. Japanese zinc smelters have reached agreement with the Ministry of International Trade and Industry on a three-year extension of the zinc stockpiling program which expired in October. The government supported stockpile purchased 123 700 t of zinc from the domestic market three years ago when the market was depressed. The goals for lead and zinc under the U.S. stockpile program were increased to 998 000 t and 1 290 000 t, respectively, but actual inventory as of March 31, 1980 was 545 300 t and 339 400 t. West Germany has announced plans to establish a permanent strategic reserve of key minerals.

Many galvanizers and other end-users of zinc are either switching or considering switching to the use of high-grade zinc from prime western now that high-grade quality is used as the producers' pricing base and is about 0.5 cents a pound less than prime western, according to a survey of users and producers. Galvanizers are continuing to expand their markets through emphasizing the advantage of corrosion-resistant products.

The makers of Renault and Peugot automobiles will substantially increase zinc usage in their cars through the increased use of galvanized sheet steel after 1982. This will enable manufacturers to guarantee a much longer life span. The decision by the French auto manufacturers follows a decision by Volkswagen to introduce cars on world markets that will be guaranteed for six years against major corrosion.

OUTLOOK

Growth of world zinc consumption since World War II was remarkably steady at over 4 per cent until the recession that started in 1973. World zinc consumption dropped sharply in the years after 1973, started recovering in 1976, but has not yet climbed back to the level of 1973.

Substitution of other materials such as aluminum and plastics for zinc has contributed to the decline in consumption. The development of thin-wall diecasting techniques has retained many zinc applications but the amount of metal used per application has fallen.

Under current recessionary forces it is expected that there will be little or no growth in zinc consumption in the next two years. The longer-term future of zinc will depend on when world economies recover and to what extent they start growing. There is no reason to expect that zinc will resume the growth rate it experienced in the 1950s and 1960s and it will probably be no more than half the former rate.

TABLE 11. INTERNATIONAL ZINC METAL PRICES, 1980

	Average Monthly Prices			
Month	Canada	U.S.	Producers Outside North America	London Metal Exchange Prompt
	(¢/lb)	(¢/lb)	($US/tonne)	(£/tonne)
January	43.0	37.4	780.0	341.8
February	44.0	37.5	801.4	380.1
March	45.0	38.0	825.0	337.1
April	44.5	38.0	822.8	320.4
May	43.0	37.5	780.0	300.5
June	41.5	36.4	780.0	290.3
July	40.5	35.5	780.0	300.7
August	40.5	35.7	780.0	324.4
September	43.5	36.6	780.0	331.6
October	44.1	37.3	803.5	333.3
November	46.0	38.6	825.0	334.8
December	49.0	40.6	825.0	334.1
1980 Average	43.7	37.4	798.2	327.4
1979 Average	43.3	37.3	792.9	349.9

Source: International Lead and Zinc Study Group Bulletin, **Northern Miner** quotes as compiled by Energy, Mines and Resources Canada.

TARIFFS

CANADA

Item No.		British Preferential	General Preferential	Most Favoured Nation	General
		(% unless otherwise specified)			
32900-1	Zinc in ores and concentrates	free	free	free	free
34500-1	Zinc dross and zinc scrap for remelting, or for processing into zinc dust	free	free	free	10
34505-1	Zinc spelter, zinc and zinc alloys containing not more than 10% by weight of other metal or metals, in the form of pigs, slabs, blocks, dust or granules	free	free	free	2¢/lb
35800-1	Zinc anodes	free	free	free	10

UNITED STATES (MFN)

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
		(% unless otherwise specified)							
602.20	Zinc in ores and concentrates	.62¢/lb	.58¢/lb	.53¢/lb	.48¢/lb	.44¢/lb	.39¢/lb	.35¢/lb	.30¢/lb
626.02	Zinc, unwrought, unalloyed	1.9	1.9	1.8	1.8	1.7	1.6	1.6	1.5
626.04	Zinc, unwrought, alloyed	19.0			- no change -				19.0
626.10	Zinc, waste and scrap	4.8	4.4	4.0	3.7	3.3	2.9	2.5	2.1

EUROPEAN ECONOMIC COMMUNITY (MFN)

		1980	Base Rate	Concession Rate
		(% unless otherwise specified)		
26.01	Zinc, ores and concentrates	free	free	free
79.01	Zinc, unwrought	3.5	3.5%	3.5%
	Zinc, waste and scrap	free	free	free

JAPAN (MFN)

26.01	Zinc, ores and concentrates	free	free	free
70.01	Zinc, unwrought, unalloyed	2.4	2.5	2.1
	Zinc, unwrought, alloyed	7.8 yen/kg	10 yen/kg	7 yen/kg
	Zinc, waste and scrap	2	2.5	1.9

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated (1980), USITC Publication 1011; U.S. Federal Register Vol. 44, No. 241; Official Journal of the European Communities, Vol. 22, No. L342, 1979; Customs Tariff Schedules of Japan, 1979; GATT Documents, 1979.

Zirconium

M.A. BOUCHER

Zirconium is obtained commercially from the mineral zircon (a zirconium silicate) and to a minor extent from the mineral baddeleyite.

Zircon has a theoretical chemical composition of 67.2 per cent ZrO_2 and 32.8 per cent SiO_2, but the mineral usually contains about 2 per cent hafnium dioxide (HfO_2); it is produced mainly in Australia, at several locations.

Baddeleyite is essentially pure zirconium dioxide with 1.0 to 1.5 per cent HfO_2; it is produced at Phalaborwa, South Africa, by Phosphate Development Corp. Ltd. (Foskor) and by Palabora Mining Co. Ltd. (PMC).

Mineable concentrations of these natural minerals are found in heavy mineral-sand deposits. Common commercial forms of the metal include the two natural minerals of zirconium, zirconium dioxide which is also known as zirconia, zirconium metal and several alloys and compounds.

Zirconium-bearing minerals are not produced in Canada and domestic requirements of zirconium minerals, as well as zirconium sub-products, are obtained entirely from imports. These products are used by a large number of companies in Canada.

Zircon is employed to make moulds in iron and steel foundries, the largest single use of the mineral. Fused cast and bonded alumina-zirconia-silica (AZS) in the form of bricks and blocks is used as a refractory in glass tank furnaces. Zirconia is consumed as a pigment in paints, chemicals and as an opacifier in glazes and enamels. Ferrozirconium is an additive in the steel industry. Zirconium metal and alloys are used by the chemical, aircraft and nuclear industries.

Zirconium products have several dominant properties that are important in a number of applications. The most important properties, along with typical applications, include: a low co-efficient of expansion and thermal conductivity-desirable in foundry moulds; resistance to abrasion - which has led to widespread use in grinding wheels; high light reflectivity - of value in paints; resistance to corrosive agents - which finds applications in the chemical industry; and low thermal neutron absorption cross section, corrosion resistance and strength - for critical applications in the nuclear industry.

CANADIAN RESOURCES

While there is no domestic production of zirconium minerals, Canada has several unexploited occurrences. These can be classified into three basic categories: (i) those associated with the tar sands; (ii) mineral sands; and (iii) those associated with igneous rocks.

TABLE 1. AUSTRALIA, ZIRCON PRODUCTION, 1970, 1975-80

	Zircon concentrate	Zircon (ZrO_2 SiO_2 content)
	(tonnes)	
1970	395 351	390 294
1975	382 217	375 548
1976	420 185	413 655
1977	398 229	393 233
1978	391 605	386 724
1979	446 980	440 119
1980P	459 038	453 000

Source: **Australian Mineral Industry Quarterly**, Volume 33 (1980), Number 4.
P Preliminary.

Tar Sands: The tar sands of Alberta, which are being mined for their crude oil content, contain approximately 0.32 tonnes (t) of zircon per one thousand t of tar sands. Syncrude Canada Ltd., one of the two domestic producers, extracts about 60 million t of tar sands[1] annually and Suncor Inc., the other domestic producer, extracts some 40 million t. Together, these two companies annually mine 100 million t of tar sands which contain about 32 000 t of zircon.

Mineral Sands: Zircon is found in a small deposit on Sable Island, off the southeast coast of Nova Scotia.

Igneous Rocks: Occurrences of zirconium minerals in igneous rocks have been noted at the following locations:

TABLE 2. WORLD[1] PRODUCTION OF ZIRCON CONCENTRATES, 1978-80

	1978	1979P	1980^e
		(tonnes)	
Australia	391 605	446 980	459 038
South Africa	36 287^e	81 647	79 832
India^e	11 167	12 428	13 426
Brazil	4 301	3 336	4 536
Sri Lanka	3 297	1 510	1 815
Malaysia	927	1 271	399
Thailand	26	86	70
Total	447 610	547 258	559 116

Source: United States Bureau of Mines **Minerals Yearbook Preprint**, Zirconium and Hafnium, 1980.

[1] No data available on production within centrally-planned-economy nations. United States production is withheld.
P Preliminary; ^{e} Estimated.

TABLE 3. WORLD MANUFACTURERS OF ZIRCONIUM SPONGE

Company	Plant Location	Annual Production Capacity 1978	1980
		(tonnes)	
Teledyne Wah Chang (TWCA)	Albany, Oregon, U.S.	3 500	3 500
Cezus (a subsidiary of Pechiney Ugine Kuhlmann)	Jarrie, France	1 000	1 600
Western Zirconium Inc.	Ogden, Utah, U.S.	Nil	1 400
Nippon Mining Co. Ltd.	Toda, Japan	50	300
Zirconium Industry Inc.	Hiratsuka, Japan	250	300
Total		4 800	7 100

Source: Personal communication from Teledyne Wah Chang

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[1] Approximately 15 t of tar sands yield 1 t of crude oil.

Location	Description
Gooderham, Ont.	Zircon crystals in pegmatite and syenite
Cardiff, Ont.	Zircon crystals in pegmatite, and in bands in calcite-pyroxenite
Brucknell, Ont.	Zircon in pegmatite
Mathilda Lake, Que.	Zircon crystals in pyroxenite
Joan Lake, Nfld.	Zircon in syenite gneiss

Although zircon is not produced in Canada some of the imported material is supplied by a Canadian company operating in South Africa. QIT-Fer et Titane Inc. of Quebec owns 31.8 per cent of the Richards Bay deposit in South Africa and the company acts as world sales agent for all production at Richards Bay, which has an annual production capacity of 115 000 t of zircon and 50 000 t of rutile.

WORLD PRODUCTION

Zircon. The world production of zircon continues to be concentrated in a few countries and Australia is the major supplier. Japan, the United States and western Europe are the principal markets.

In 1980, world production of zircon was 559 116 t compared with 547 258 t in 1979. Australian production, which increased from 446 980 t in 1979 to 459 038 t in 1980, accounted for 82 per cent of 1980 world output.

In the United States, zircon was recovered from mineral sands as a coproduct of titanium mineral concentrates by E.I. Du Pont de Nemours & Co., Inc. at Starke and Highland, Florida, and Associated Minerals Consolidated Ltd. (AMC) at Green Cove Springs, Florida. Production data from these companies are withheld to avoid disclosing company proprietary data. The combined annual production capacity of the two companies is estimated to be 100 000 t of zircon.

In South Africa, production at Richards Bay is expected to reach the annual capacity rate of 115 000 t in 1981-82. South Africa produced an estimated 79 832 t of zircon concentrates during 1980.

Zirconium. The major suppliers of zirconium in 1980 were Teledyne Wah Chang (TWCA) in the United States and Cezus, a subsidiary of Pechiney Ugine Kuhlmann of France (Table 3). Cezus was operating at near-capacity in 1980 while a considerable amount of available capacity remained idle in the United States. Licensing regulations in the United States for exports of nuclear-grade zirconium mill products have at times been an obstacle to foreign sales.

Western world consumption of zirconium ingot in 1980 was an estimated 3 260 t for nuclear power stations, and 900 t for military requirements and non-nuclear applications such as processing equipment in the chemical industry.

CANADIAN CONSUMPTION OF ZIRCONIUM PRODUCTS

Zircon. Canada imports 27 000 to 30 000 tonnes per year (tpy) of zircon concentrates, mainly from Australia but also from the United States. Small amounts of baddeleyite concentrates are imported from South Africa.

Zircon is used mainly to make cores and facings on foundry moulds. Important consumers include Abex Industries Ltd., Haley Industries Limited and Dofasco Inc.

Baddeleyite is used to make artificial abrasives. An important Canadian producer of such abrasives is the Norton Company at Niagara Falls, Ontario. Baddeleyite is also used to make zirconium metal and refractory materials.

Zirconia. Baddeleyite concentrate containing about 96 per cent zirconia (ZrO_2) is mixed with fused alumina and smelted in electric furnaces. The resulting product, an artificial abrasive called zirconia-alumina, contains 75 per cent Al_2O_3 and 25 per cent ZrO_2, and is used to make grinding wheels. The electrical energy consumption in the process is about 2 200 kilowatt hours (kwh) per t of zirconia-alumina.

Zirconia-alumina-silica, bonded or fused cast, is used to make bricks and blocks for glass tank furnaces. Two common types of bricks used in glass tank furnaces have the following chemical compositions:

TABLE 4. FORECAST OF WORLD DEMAND FOR ZIRCONIUM FOR NUCLEAR END-USES

Country	1980	1985	1990
	(tonnes)		
United States	1 450	2 270	3 220
Japan	300	650	980
Canada	300	520	770
France	270	470	780
West Germany	180	480	560
Other western world	480	1 110	1 870
Communist countries	280	450	620
World	3 260	5 950	8 800

Source: **Roskill Letter from Japan,** April 1981.

TABLE 5. FORECAST OF WORLD ELECTRICAL ENERGY GENERATING CAPACITY IN YEAR 2000

Process	Gigawatt (10^9 watts)
Nuclear	5 000
Coal	2 750
Hydro	1 750
Oil, gas, geothermal, solar	1 500
Total	11 000

Source: C.M.E., **World Energy: Looking Ahead to 2020,** IPC Science, New York, 1978, p. 233.

TABLE 6. CANADA, ZIRCONIUM IMPORTS BY COUNTRY

	1978		1979		1980	
	tonnes	$000	tonnes	$000	tonnes	$000
Zircon sand and flour						
Australia	30 537	4,046	26 118	2,502	25 575	2,404
U.S.	966	260	2 405	572	1 955	537
Total	31 503	4,306	28 523	3,074	27 530	2,941
Zirconium oxides						
U.S.	20	127	143	184	64	101
Total	21	131	143	184	64	101
Zirconium silicate						
U.S.	723	418	712	373	921	558
Total	795	449	748	391	956	575
Ferrozirconium alloys						
U.S.	70	164	246	461	w	w
Total	70	164	382	661	232	440
	kg		kg		kg	
Zirconium, primary forms and fabricated material						
U.S.	143 081	5,141	54 962	2,218	48 096	2,794
Total	143 976	5,183	55 671	2,248	48 677	2,827
Zirconium alloys						
U.S.	318 786	8,537	275 985	12,349	190 207	11,274
France	6 972	292	35 649	1,731	38 791	1,977
Sweden	-	-	584	42	-	-
U.K.	500	3	-	-	-	-
Total	326 258	8,832	312 218	14,122	228 998	13,251

Source: Statistics Canada.

W: Withheld to avoid disclosing confidential company data; - Nil.

TABLE 7. CHEMICAL AND SIZE ANALYSIS OF ZIRCON CONCENTRATES OF TYPICAL PRODUCERS

	Australia (East Coast)		U.S. (Florida)		South Africa		
					Zircon		Baddeleyite
	Standard	Premium	Standard	Premium	Standard	Premium	
Chemical Guarantee							
% ZrO_2 Mn	65.5	66.0	65.0	66.0	65.0	66.0	95-97
% Fe_2O_3 Mx	0.05	0.05	0.1	0.04	0.3	0.05	0.4-1.0
% TiO_2 Mx	0.3	0.1	0.35	0.2	0.3	0.1	0.5-1.0
% Al_2O_3 Mx	0.4	0.3	2.0	0.5	0.25	0.08	0.1
Typical Screen Sizings microns (% cumulative)							
250	0	1	-	-	0.5	0.5	
180	1	6	5	-	0.7	0.7	
125	12	45	41	Traces	29.8	29.8	
90	67	95	84	56	80.0	80.0	
63	99	100	100	93	100.0	100.0	
53	100	-	-	100	-	-	

Source: Producers' Published Specifications.

Mn Minimum; Mx Maximum.

Chemical Composition	Trade Name	
	Zirmul	Monofrax
	(per cent)	
Al_2O_3	70.0	34.20
ZrO_2	19.5	50.13
SiO_2	10.2	14.25
Others	0.3	1.42

The major consumers of these bricks in Canada are Consumers Glass Company, Limited and Domglas Inc.

Zirconium Metal and Alloy

Imports of zirconium metal and alloys in 1980 amounted to 278 t valued at some $16 million.

Several companies in Canada are involved in the fabrication and assembly of zirconium metal and alloys parts for the construction of nuclear reactors. A list of these companies is shown in Table 8.

All of the zirconium metal and alloys consumed in Canada are imported, mainly from the United States but also from France. A substantial portion of these materials, following processing and fabrication, is used by Ontario Hydro in its nuclear reactors, and the remainder is exported.

A list of CANDU nuclear reactors in operation or under construction in the world is shown in Table 10. A 600 MW nuclear reactor costs about $1 billion in 1980 dollars and can supply the energy necessary for about 600,000 households.

The construction of such a reactor initially requires 33.2 t of zirconium metal in the form of fuel cladding, strip, etc. and pressure tubes. Thereafter some 15 t of zirconium metal in the form of fuel cladding, strip, etc. must be replaced annually. A more detailed account of zirconium consumption in a Candu reactor is given in Table 9.

PRICES

The price of zirconium continued to increase due to the rising cost of raw materials, energy and labour. Zircon sand originating in Australia and delivered to foundries in eastern Canada cost $210-230 per t in 1980. At year-end zirconium sponge cost $US 22 to $US 30 a kilogram.

TABLE 8. CANADIAN ZIRCONIUM MANUFACTURING AND ASSEMBLY FACILITIES

Company	Location	Type of operation
Canadian General Electric Company Limited (CGE)	Peterborough, Ont.	Fuel bundle fabrication and assembly
Westinghouse Canada Inc.	Port Hope, Ont.	Fuel bundle fabrication and assembly
	Varennes, Que.	Fuel bundle fabrication and assembly
Combustion Engineering-Superheater Ltd.	Moncton, N.B.	Fuel bundle fabrication and assembly
Noranda Metal Industries Ltd.	Arnprior, Ont.	Fuel cladding (tube) production
Westinghouse Canada Inc.	Port Hope, Ont.	Fuel cladding (tube) production
Chase Nuclear (Canada) Ltd.	Arnprior, Ont.	Pressure tubes "finishing"
Westinghouse Canada Inc.	Port Hope, Ont.	Calandria tubes production
Bristol Aerospace Limited	Winnipeg, Man.	Calandria tubes production

Source: Energy, Mines and Resources Canada.

TABLE 9. ZIRCONIUM ALLOY REQUIREMENTS - 600 MWE CANDU-PHW

Fuel cladding

Initial fuel charge: 4,600, 37-element fuel bundles
Fuelling rate: approximately 6,500 bundles/year
Total zirconium alloy weight : 2.3 kg Zircaloy - 4[1] (per bundle)
- of which fuel cladding : 2.15 kg Zircaloy - 4 (per bundle)
other (strip, bar stock) : 0.15 kg Zircaloy - 4 (per bundle)

Cladding size: : 13.12 mm OD, 0.38 mm wall, 500 mm long
Tubing requirement : initial charge 85 000 metres weighing 9.8 Mg. Annual replacement 120 250 metres weighing 13.9 Mg.

Pressure Tubes

Number of pressure tubes : 380
Material : 97.5% Zirconium and 2.5% niobium alloy
Pressure tube size : 103.38 mm ID, 4.32 mm wall, 6.3 metres long
weight : 61.1 kg
Requirement per reactor : 2 400 metres weighing 23.2 Mg

Source: Atomic Energy of Canada Limited.

Mg = megagrams
= 1 metric tonne.

[1] A nuclear grade alloy of zirconium.

At the end of 1980 zircon prices, as quoted in **Metals Week** and **American Metal Market** were as follows:

	Price per kg ($US)
Zirconium ore	
Australia	0.171
United States	0.182
Sponge	22.046 - 30.865
Sheet, strip, bar	44.092 - 77.162

OUTLOOK

New mining developments in the world, especially in South Africa, will significantly increase the number of suppliers of zircon concentrates. As a result, Australian producers of zircon could have more difficulty competing in Europe and the United States in the future.

The surplus production capacity for zirconium metal that developed during 1980 in the United States is expected to continue for several years. While production capacity in the United States has increased considerably in recent years, demand growth in the nuclear industry has been moderate due to environmental problems and licensing delays. If these constraints continue to be a problem, the demand in the United States by 1985 may fall much below the forecast shown in Table 4.

Although the demand for zirconium metal in western Europe and Japan has increased considerably in recent years, supply has increased only moderately. Capacity expansions and the entry of new producers in these countries is a definite possibility during the course of the next few years.

TABLE 10. CANDU PHW NUCLEAR ELECTRIC GENERATING STATIONS IN OPERATION OR UNDER CONSTRUCTION

Name	Location	Power MW(e) Net	Date of First Power
NPD 2	Ontario	22	1962
Douglas Pt.	Ontario	206	1967
Pickering A 1	Ontario	515	1971
Pickering A 2	Ontario	515	1971
Pickering A 3	Ontario	515	1972
Pickering A 4	Ontario	515	1973
KANUPP	Pakistan	125	1971
RAPP 1	India	203	1972
RAPP 2	India	203	1980
Bruce A 1	Ontario	740	1977
Bruce A 2	Ontario	740	1977
Bruce A 3	Ontario	740	1978
Bruce A 4	Ontario	740	1979
Gentilly 2	Quebec	638	1982
Pt. Lepreau	New Brunswick	633	1982
Cordoba	Argentina	600	1982
Pickering B 5	Ontario	516	1983
Pickering B 6	Ontario	516	1983
Pickering B 7	Ontario	516	1984
Pickering B 8	Ontario	516	1984

TABLE 10. (cont'd)

Name	Location	Power MW(e) Net	Date of First Power
Wolsung 1	Korea	629	1982
Bruce B 5	Ontario	786	1984
Bruce B 6	Ontario	756	1983
Bruce B 7	Ontario	756	1986
Bruce B 8	Ontario	756	1987
Cernavoda	Romania	600	1985
Darlington 1	Ontario	881	1988
Darlington 2	Ontario	881	1989
Darlington 3	Ontario	881	1989
Darlington 4	Ontario	881	1990

Source: Atomic Energy of Canada Ltd.

TARIFFS

CANADA

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(%)		
34720-1	Sponge and sponge briquettes, ingots, blooms, slabs, billets and castings in the rough, of zirconium or zirconium alloys for use in Canadian manufacture (expires June 30, 1981)	free	free	25	free
34730-1	Bars, rods, plate, sheet, strip, wire, forgings, castings, foils and tubes, seamless or welded, of zirconium or zirconium alloys for use in the manufacture of nuclear power reactors, including fuels components (expires June 30, 1981)	free	free	25	free
33508-1	Zirconium oxide	free	4.9	15	free
92845-4	Zirconium silicate	free	free	free	free

MFN Reductions under GATT (effective January 1 of year given)

Item No.	1980	1981	1982	1983	1984	1985	1986	1987
				(%)				
33508-1	4.9	4.8	4.6	4.5	4.4	4.3	4.1	4.0

TARIFFS (cont'd)

UNITED STATES

Item No.		1980	1981	1982	1983	1984	1985	1986	1987
601.63	Zirconium ore, (including zirconium sand)				free				
					(%)				
629.60	Zirconium metal, unwrought, waste and scrap, other than alloys (duty on waste and scrap suspended to June 30, 1981)	5.8	5.6	5.3	5.1	4.9	4.7	4.4	4.2
629.62	Zirconium, unwrought alloys	7.2	6.9	6.5	6.2	5.9	5.6	5.2	4.9
629.65	Zirconium metal, wrought	8.6	8.1	7.7	7.3	6.8	6.4	5.9	5.5
422.80	Zirconium oxide	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7
422.82	Other zirconium compounds	4.8	4.7	4.5	4.4	4.2	4.0	3.9	3.7

EUROPEAN ECONOMIC COMMUNITY

Item No.		1980	Base Rate	Concession Rate
			(%)	
26.01	Zirconium and hafnium ores	free		
28.28	Zirconium oxide	7.9	8.0	7.0
28.45	Zirconium silicates	8.4	8.8	5.7
73.02	Ferrozirconium	5.7	7.0	4.9
81.04	Zirconium metal			
	Unwrought; waste and scrap	5.9	6.0	5.0
	Wrought	9.9	10.0	9.0

Sources: The Customs Tariff and Commodities Index, January 1980, Revenue Canada; Tariff Schedules of the United States Annotated 1980, USITC Publication 1011; U.S. Federal Register, Vol. 44, No. 241; Official Journal of the European Communities, Vol. 22, No. L342, 1979.

Statistical Summary of the Mineral Industry in Canada

In January 1979, the responsibility for Canadian mineral statistics was transferred from Statistics Canada to the Department of Energy, Mines and Resources. The first annual statistical report of this nature on the Canadian mineral industry was published by the Geological and Natural History Survey of Canada in 1886 and later by the Mines Branch of the Department of Mines until 1920. In 1921, the Dominion Bureau of Statistics, later Statistics Canada, assumed the responsibility and continued to publish the reports until 1978.

The statistical material contained in this summary was principally derived from surveys conducted by the Information Systems Division of the Mineral Policy Sector of Energy, Mines and Resources Canada.

The statistical survey program of Energy, Mines and Resources Canada is conducted jointly with the provincial governments and Statistics Canada. This joint program is intended to minimize the reporting burden on the mineral companies. The cooperation of the companies that provide information is greatly appreciated. Without this cooperation, a statistical report of this nature would not be possible. International mineral statistics contained in this summary are derived from the U.S. Bureau of Mines, The American Bureau of Metal Statistics, The World Bureau of Metal Statistics, **Metals Week, Engineering and Mining Journal,** The United Nations and the Organization for Economic Co-operation and Development (OECD).

This statistical summary of the mineral industry in Canada for the year 1980 was prepared by J.T. Brennan and staff, Statistics Section, Mineral Policy Sector, Energy, Mines and Resources Canada, Ottawa. Telephone (613) 995-9466.

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CANADA, GENERAL ECONOMIC

		1966	1967	1968	1969	1970
Gross national product, current dollars	($ million)	61,828	66,409	72,586	79,815	85,685
Gross national product, constant dollars (1971 = 100)	"	74,844	77,344	81,864	86,225	88,390
Value of manufacturing industry shipments	"	37,303	38,955	42,062	45,930	46,381
Value of mineral production	"	3,981	4,381	4,722	4,734	5,722
Merchandise exports	"	10,071	11,112	13,270	14,498	16,401
Merchandise imports	"	10,072	10,873	12,358	14,130	13,952
Balance of payments, current account	"	-1,162	-499	-97	-917	+1,106
Corporation profits before taxes	"	6,714	6,823	7,742	8,294	7,699
Capital investment current dollars	"	15,088	15,348	15,455	16,927	17,798
Capital investment, constant dollars (1971 = 100)	"	17,645	17,571	17,628	18,498	18,635
Population	000's	20,015	20,378	20,701	21,001	21,297
Labour force	"	7,420	7,694	7,919	8,162	8,395
Employed	"	7,152	7,379	7,537	7,780	7,919
Unemployed	"	267	315	382	382	476
Unemployment rate	%	3.6	4.1	4.8	4.7	5.7
Employment index	1961=100	120.7	122.6	122.7	127.0	127.1
Labour income	($ million)	31,878	35,303	38,444	43,065	46,706
Index industrial production	1971=100	79.2	82.3	87.6	93.6	94.9
Index manufacturing production	"	81.5	83.9	89.1	95.8	94.5
Index mining production	"	74.1	79.9	86.2	86.9	98.7
Index real domestic product	"	79.5	82.3	86.9	92.2	94.4
Consumer price index	1971=100	83.5	86.5	90.0	94.1	97.2

^{p} Preliminary; ^{r} Revised.

INDICATORS, 1966-80

1971	1972	1973	1974	1975	1976	1977	1978	1979	1980P
94,450	105,234	123,560	147,528	165,343	191,031	208,806	230,353^r	261,961	289,859
94,450	100,248	107,812	111,678	113,005	119,249	121,823	126,281^r	130,115	130,160
50,276	56,191	66,674	82,455	88,427	98,076	109,747	129,019^r	152,133	165,985
5,963	6,408	8,370	11,754	13,347	15,693	18,473	20,261	26,081	32,368
17,397	19,671	24,838	31,739	32,587	37,651	43,685	52,259	64,317	74,259
15,617	18,669	23,325	31,722^r	34,715^r	37,494	42,363	50,107^r	62,871	69,128
+431	-386	+108	-1,460	-4,757^r	-3,842	-4,301	-4,935^r	-4,894	-1,904
8,681	10,799	15,417	20,062	19,663	19,985	21,090	25,360	34,884	37,172
20,184	22,218	26,618	32,882	38,216	43,636	46,597	50,360	58,355	65,412
20,184	21,242	23,551	24,927	25,694	26,727	26,527	26,546	28,021	28,939
21,568	21,802	22,043	22,364	22,697	22,993	23,258	23,476	23,671	23,914
8,639	8,897	9,276	9,639	9,974	10,206	10,498	10,882	11,207	11,522
8,104	8,344	8,761	9,125	9,284	9,479	9,648	9,972	10,369	10,655
535	553	515	514	690	727	850	911	838	867
6.2	6.2	5.5	5.3	6.9	7.1	8.1	8.4	7.5	7.5
127.8	129.9	135.9	142.8	141.1	144.1	144.3	146.5	150.7	152.4
51,528	57,570	66,501	79,846^r	93,299	107,922^r	118,992^r	129,848^r	145,091	162,373
100.0	107.5	118.1	122.2	114.9	121.2^r	123.9^r	129.0^r	135.0	132.8
100.0	107.1	117.6	122.0	114.3	120.6^r	122.2^r	129.2^r	134.2	130.6
100.0	106.5	119.3	117.3	107.1	109.8	114.0	105.3	116.3	118.3
100.0	105.5	113.6	119.0	119.8	126.2^r	129.7^r	134.3^r	138.5	138.8
100.0	104.8	112.7	125.0	138.5	148.9	160.8	175.2	191.2	210.6

TABLE 1. MINERAL PRODUCTION OF CANADA, 1979 AND 1980, AND AVERAGE 1976-80

	Unit of Measure	1979		1980P		Average 1976-80	
		(Quantity)	($'000)	(Quantity)	($'000)	(Quantity)	($'000)
Metals							
Antimony	t	..	8,350	..	6,503	..	8,115
Bismuth	t	137	974	171	1,269	150	1,532
Cadmium	t	1 209	8,621	1 053	7,790	1 182	7,868
Calcium	t	456	2,152	525	3,033	512	2,222
Cobalt	t	1 640	109,344	1 603	95,019	1 464	53,824
Columbium (Cb_2O_5)	t	2 513	15,292	2 330	15 005	2 265	12,831
Copper	000 t	636	1,511,200	708	1,856,031	699	1,343,057
Gold	kg	51 142	590,766	48 284	1,020,151	51 987	494,789
Indium	kg	..	..	..	..	..	..
Iron ore	000 t	59 617	1,807,399	50 866	1,722,812	52 490	1,470,076
Iron remelt	000 t	..	61,067	..	125,912	..	83,640
Lead	000 t	311	410,518	274	299,518	288	258,457
Magnesium	t	9 015	24,444	8 899	27,037	7 990	20,380
Mercury	t	-	-	-	-	-	-
Molybdenum	t	11 175	332,024	12 198	315,423	13 701	215,134
Nickel	000 t	126	828,617	195	1,678,607	185	1,100,345
Platinum group	kg	6 157	56,334	12 584	155,480	11 390	77,848
Selenium	t	218	6,908	246	11,296	171	6,775
Silver	kg	1 146 908	478,400	1 037 000	817,961	1 209 191	386,519
Tantalum (Ta_2O_5)	t	159	14,521	127	22,500	..	..
Tellurium	t	42	2,192	45	1,240	40	1,504
Tin	t	337	5,565	264	5,898	313	4,398
Tungsten (WO_3)	t	3 254	..	4 650	..	3 048	..
Uranium (U)	t	6 530	616,168	6 368	637,717	6 467	492,492
Zinc	000 t	1 100	1,060,103	895	859,880	1 023	878,131
Total metals			7,950,959		9,685,698		6,919,937
Nonmetals							
Arsenious oxide	t	..	..	..	..	..	..
Asbestos	000 t	1 493	607,461	1 335	641,737	1 461	559,468
Barite	000 t	..	1,953	..	2,562	..	2,372
Feldspar	000 t	-	-	-	-	-	-
Fluorspar	000 t	-	-	-	-	-	2,324
Gemstones	t	..	1,391	..	1,470	..	1,384
Gypsum	000 t	8 098	41,126	7 209	43,670	7 323	35,513
Magnesitic dolomite and brucite	000 t	..	8,990	..	10,405	..	7,137
Mica	kg	..	..	..	..	..	..
Nepheline syenite	000 t	606	15,180	592	15,877	582	13,558

Peat	000 t	480	41,150	488	42,506	437	34,510
Potash (K_2O)	000 t	7 074	735,247	7 532	986,220	6 386	596,643
Pyrite, pyrrhotite	000 t	31	275	32	345	25	226
Quartz	000 t	2 368	26,579	2 624	29,318	2 374	22,592
Salt	000 t	6 881	109,848	7 029	125,845	6 479	101,635
Soapstone, talc & pyrophyllite	000 t	90	3,439	87	3,086	76	2,559
Sodium sulphate	000 t	443	25,211	496	28,930	434	23,440
Sulphur in smelter gas	000 t	667	14,515	903	22,955	737	16,373
Sulphur, elemental	000 t	6 314	159,642	7 403	414,484	5 741.	165,259
Titanium dioxide	000 t	..	75,670	..	110,559	..	85,065
Total nonmetals			1,867,677		2,479,969		1,670,058
Fuels							
Coal	000 t	33 200	860,000	36 500	946,000	30 835	760,409
Natural gas	000 m^3	94 426 000	4,855,845	84 402 000	6,692,200	89 321 151	4,308,560
Natural gas by-products	000 m^3	19 664	1,449,015	18 738	1,741,474	17 607	1,204,558
Oil, crude	000 m^3	86 910	7,451,855	84 198	9,098,104	80 095	6,257,269
Total fuels			14,616,715		18,477,778		12,530,796
Structural materials							
Clay products	000 $	..	121,526	..	114,266	..	109,449
Cement	000 t	11 765	653,877	10 497	657,402	10 395	537,114
Lime	000 t	1 859	82,774	2 063	102,810	1 957	77,588
Sand and gravel	000 t	285 221	457,120	327 860	511,582	279 447	416,971
Stone	000 t	109 719	330,708	103 281	339,438	108 637	306,019
Total structural materials			1,646,005		1,725,498		1,447,141
Total, all minerals			26,081,356		12,368,943		22,567,932

Notes: [1] Production statistics for the following are not available for publication: diatomite, helium, nitrogen and yttrium. [2] Nil production for the following between 1976 and 1980: feldspar, grindstone, iron oxide, lithia and thorium. [3] Dollar values only available for publication for the following: antimony, iron remelt, barite, gemstones, magnesitic dolomite and brucite, titanium dioxide and clay products.
P Preliminary; .. Not available or not applicable; - Nil.

TABLE 2. CANADA, VALUE OF MINERAL PRODUCTION, PER CAPITA VALUE OF MINERAL PRODUCTION, AND POPULATION, 1951-80

	Metallics	Industrial Minerals	Fuels	Total	Per Capita Value of Mineral Production	Population of Canada
		($ million)			($)	(000)
1951	746	266	233	1,245	88.90	14,009
1952	728	293	264	1,285	88.90	14,459
1953	710	312	314	1,336	90.02	14,845
1954	802	333	353	1,488	97.36	15,287
1955	1,008	373	414	1,795	114.37	15,698
1956	1,146	420	519	2,085	129.65	16,081
1957	1,159	466	565	2,190	131.87	16,610
1958	1,130	460	511	2,101	122.99	17,080
1959	1,371	503	535	2,409	137.79	17,483
1960	1,407	520	566	2,493	139.48	17,870
1961	1,387	542	674	2,603	142.72	18,238
1962	1,496	574	811	2,881	155.05	18,583
1963	1,510	632	885	3,027	159.91	18,931
1964	1,702	690	973	3,365	174.45	19,291
1965	1,908	761	1,046	3,715	189.11	19,644
1966	1,985	844	1,152	3,981	198.88	20,015
1967	2,285	861	1,235	4,381	214.99	20,378
1968	2,493	886	1,343	4,722	228.10	20,701
1969	2,378	891	1,465	4,734	225.42	21,001
1970	3,073	931	1,718	5,722	268.68	21,297
1971	2,940	1,008	2,015	5,963	276.46	21,568
1972	2,956	1,085	2,367	6,408	293.92	21,802
1973	3,850	1,293	3,227	8,370	379.69	22,043
1974	4,821	1,731	5,202	11,754	525.55	22,364
1975	4,796	1,898	6,653	13,347	588.05	22,697
1976	5,315	2,269	8,109	15,693	682.51	22,993
1977	5,988	2,612	9,873	18,473	794.26	23,258
1978	5,698	2,986	11,577	20,261	863.05	23,476
1979	7,951	3,514	14,617	26,081	1,101.81	23,671
1980P	9,686	4,205	18,478	32,369	1,353.56	23,914

P Preliminary.

TABLE 3. CANADA, VALUE OF MINERAL PRODUCTION BY PROVINCES, TERRITORIES AND MINERAL CLASSES, 1980P

	Metals		Industrial Minerals		Fuels		Total	
	($000)	(% of total)	($000)	(% of total)	($000)	(% of total)	($000)	(% of total)
Alberta	-	0.0	616,776	14.7	16,228,474	87.8	16,845,250	52.0
Ontario	3,869,293	39.9	756,344	18.0	34,935	0.2	4,660,572	14.4
British Columbia	1,479,727	15.3	306,616	7.3	1,006,163	5.4	2,792,506	8.6
Quebec	1,408,240	14.5	1,092,845	26.0	-	-	2,501,085	7.7
Saskatchewan	254,587	2.6	1,084,098	25.8	951,662	5.2	2,290,347	7.1
Newfoundland	1,012,269	10.5	71,050	1.7	-	-	1,083,319	3.3
Manitoba	677,657	7.0	101,248	2.4	55,263	0.3	834,168	2.6
New Brunswick	327,457	3.4	57,408	1.4	17,355	0.1	402,220	1.2
Northwest Territories	337,199	3.5	-	-	53,426	0.3	390,625	1.2
Yukon	302,953	3.1	-	-	-	-	302,953	0.9
Nova Scotia	16,316	0.2	116,475	2.8	130,500	0.7	263,291	0.8
Price Edward Island	-	-	2,607	0.1	-	-	2,607	-
Total, Canada	9,685,698	100.0	4,205,467	100.0	18,477,778	100.0	32,368,943	100.0

P Preliminary; - Nil.

TABLE 4. CANADA, PRODUCTION OF LEADING MINERALS

	Unit of measure	Nfld.	P.E.I.	Nova Scotia	New Brunswick	Quebec	Ontario
Oil, crude	000 m^3	-	-	-	1	-	97
	$000	-	-	-	40	-	9,447
Natural gas	000 m^3	-	-	-	2	-	328
	$000	-	-	-	15	-	25,488
Copper	000 t	6	-	-	10	101	233
	$000	15,182	-	-	25,286	265,809	611,232
Natural gas byproducts	000 m^3	-	-	-	-	-	-
	$000	-	-	-	-	-	-
Iron ore	000 t	26 194	-	-	-	17 447	6 524
	$000	939,938	-	-	-	506,916	262,578
Nickel	000 t	-	-	-	-	-	156
	$000	-	-	-	-	-	1,312,139
Gold	kg	x	-	-	x	16	18
	$000	5,824	-	-	5,803	348,152	387,925
Potash (K_2O)	000 t	-	-	-	-	-	-
	$000	-	-	-	-	-	-
Coal	000 t	-	-	2 680	440	-	-
	$000	-	-	130,500	17,300	-	-
Zinc	000 t	40	-	5	144	73	263
	$000	38,804	-	4,382	138,533	69,928	252,409
Silver	kg	9	-	-	124	60	450
	$000	7,408	-	-	97,649	47,038	354,161
Cement	000 t	..	-	..	..	2 278	4 283
	$000	6,452	-	17,280	14,002	134,708	225,594
Asbestos	000 t	64	-	-	-	1 169	-
	$000	38,925	-	-	-	518,714	-
Uranium (U)	t	-	-	-	-	-	4
	$000	-	-	-	-	-	413,481
Sand and gravel	000 t	11 000	1 212	11 500	8 819	57 916	121 254
	$000	16,500	2,607	27,600	14,800	70,274	174,900
Sulphur, elemental	000 t	-	-	-	-	-	22
	$000	-	-	-	-	-	1,200
Stone	000 t	1 361	-	2 359	3 266	55 336	34 019
	$000	3,375	-	8,450	10,800	178,773	112,500
Molybdenum	t	-	-	-	-	1	-
	$000	-	-	-	-	18,491	-
Lead	t	4	-	11	49	x	10
	$000	4,707	-	11,934	53,170	117	11,217
Platinum group	kg	-	-	-	-	-	13
	$000	-	-	-	-	-	155,480
Salt	000 t	-	-	1 018	-	-	4 800
	$000	-	-	27,862	-	-	72,358
Clay products	$000	778	-	6,023	2,667	17,511	59,527
Titanium dioxide	000 t	-	-	-	-	..	-
	$000	-	-	-	-	110,559	-
Lime	000 t	-	-	-	..	393	1 295
	$000	-	-	-	3,415	21,774	60,590
Cobalt	t	-	-	-	-	-	1
	$000	-	-	-	-	-	70,110
Total leading minerals	$000	1,077,893	2,607	234,031	383,480	2,308,764	4,572,336
Total all minerals	$000	1,083,319	2,607	263,291	402,220	2,501,085	4,660,572
Leading minerals as % of all minerals		99.5	100.0	88.9	95.3	92.3	98.1

P Preliminary; - Nil; .. Not available; x less than 1 unit amount.

BY PROVINCES AND TERRITORIES, 1980P

Manitoba	Saskat- chewan	Alberta	British Columbia	Yukon	N.W.T.	Total Canada
568	9 566	71 758	2 030	-	178	84 198
55,263	880,548	7,948,485	192,001	-	12,320	9,098,104
-	1 470	73 321	8 851	-	430	84 402
-	27,371	6,279,598	318,622	-	41,106	6,692,200
66	5	-	276	11	x	708
172,255	14,261	-	723,697	27,522	787	1,856,031
-	140	18 288	310	-	-	18 738
-	12,943	1,697,791	30,740	-	-	1,741,474
-	-	-	701	-	-	50 866
-	-	-	13,380	-	-	1,722,812
39	-	-	-	-	-	195
366,468	-	-	-	-	-	1,678,607
1	x	-	7	1	3	48
29,369	7,229	-	153,491	19,484	62,874	1,020,151
-	7,523	-	-	-	-	7 523
-	986,220	-	-	-	-	986,220
-	5 680	17 400	10 300	-	-	36 500
-	30,800	302,600	464,800	-	-	946,000
40	5	-	62	76	186	895
38,925	4,360	-	60,036	73,307	179,196	859,880
27	5	-	188	128	46	1 037
21,469	4,215	-	148,488	101,165	36,368	817,961
567	304	1 197	1 258	-	-	10 497
45,940	30,881	99,088	83,457	-	-	657,402
-	-	-	102	-	-	1 335
-	-	-	84,098	-	-	641,737
-	2	-	-	-	-	6
-	224,236	-	-	-	-	637,717
18 188	14 771	32 000	51 200	-	-	327 860
33,165	21,976	67,840	81,920	-	-	511,582
-	2	7 245	134	-	-	7 403
-	60	405,720	7,504	-	-	414,484
2 177	-	227	4 536	-	-	103 281
8,040	-	1,250	16,250	-	-	339,438
-	-	-	12	-	-	12
-	-	-	296,932	-	-	315,423
x	-	-	72	75	53	274
433	-	-	78,107	81,475	57,974	299,134
-	-	-	-	-	-	13
-	-	-	-	-	-	155,480
-	349	862	-	-	-	7 029
-	14,456	11,169	-	-	-	125,845
1,139	3,290	11,581	11,750	-	-	114,266
-	-	-	-	-	-	..
-	-	-	-	-	-	110,559
..	-	183	64	-	-	2 063
4,158	-	9,041	3,832	-	-	102,810
x	-	-	-	-	-	2
24,909	-	-	-	-	-	95,019
801,533	2,262,846	16,834,163	2,769,105	302,953	390,625	31,940,336
834,168	2,290,347	16,845,250	2,792,506	302,953	390,625	32,368,943
96.1	98.8	99.9	99.2	100.0	100.0	98.7

TABLE 5. CANADA, PERCENTAGE CONTRIBUTION OF LEADING MINERALS TO TOTAL VALUE OF MINERAL PRODUCTION, 1974-80

	1974	1975	1976	1977	1978	1979	1980P
Oil, crude	30.0	28.2	25.8	26.4	28.7	28.6	28.1
Natural gas	6.2	11.4	16.9	18.5	19.4	18.6	20.7
Copper	11.9	7.7	7.0	6.3	5.4	5.8	5.7
Natural gas byproducts	5.6	5.9	5.1	5.3	5.3	5.5	5.4
Iron ore	6.2	6.9	7.8	7.5	6.0	6.9	5.3
Nickel	8.3	8.3	7.3	6.6	3.1	3.2	5.2
Gold	2.2	2.0	1.3	1.5	1.9	2.3	3.2
Potash (K_2O)	2.6	2.7	2.3	2.2	2.5	2.8	3.0
Coal	2.6	4.4	3.9	3.3	3.8	3.3	2.9
Zinc	7.4	6.5	5.2	4.5	4.0	4.1	2.7
Silver	1.7	1.3	1.1	1.1	1.2	1.8	2.5
Cement	2.4	2.5	2.4	2.3	2.8	2.5	2.0
Uranium (U)	...	...	1.5	1.9	3.1	2.4	2.0
Asbestos	2.6	2.0	2.9	3.1	2.6	2.3	2.0
Sand and gravel	2.3	2.3	2.1	2.0	2.1	1.8	1.6
Sulphur, elemental	0.6	0.7	0.5	0.4	0.5	0.6	1.3
Stone	1.5	1.5	1.5	1.6	1.6	1.3	1.0
Molybdenum	0.5	0.5	0.6	0.8	0.9	1.3	1.0
Lead	1.1	1.2	0.8	1.1	1.3	1.6	0.9
Platinum group	0.5	0.4	0.3	0.3	0.3	0.2	0.5
Clay products	0.6	0.6	0.6	0.6	0.5	0.5	0.4
Salt	0.5	0.5	0.5	0.5	0.5	0.4	0.4
Cobalt	0.1	0.1	0.1	0.1	0.2	0.4	0.3
Lime	0.4	0.3	0.4	0.4	0.4	0.3	0.3
Titanium dioxide	0.4	0.4	0.5	0.4	0.4	0.3	0.3
Other minerals	1.8	1.7	1.6	1.3	1.5	1.2	1.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

P Preliminary; ... Too small to be expressed.

TABLE 6. CANADA, VALUE OF MINERAL PRODUCTION BY PROVINCES AND TERRITORIES, 1974-80

	1974	1975	1976	1977	1978	1979	1980P
				($ million)			
Alberta	4,517	5,750	6,934	8,576	10,087	12,899	16,845
Ontario	2,435	2,354	2,712	2,980	2,698	3,265	4,661
British Columbia	1,156	1,296	1,606	1,687	1,883	2,677	2,793
Quebec	1,222	1,232	1,493	1,675	1,796	2,165	2,501
Saskatchewan	791	862	974	1,208	1,582	1,874	2,290
Newfoundland	448	551	745	867	675	1,125	1,083
Manitoba	489	530	511	564	459	653	834
New Brunswick	217	232	239	289	339	480	402
Northwest Territories	223	206	225	236	310	435	391
Yukon	171	230	125	210	219	299	303
Nova Scotia	83	102	127	199	211	210	263
Prince Edward Island	1	2	2	2	2	2	3
Total	11,753	13,347	15,693	18,473	20,261	26,084	32,369

P Preliminary.

TABLE 7. CANADA, PERCENTAGE CONTRIBUTION OF PROVINCES AND TERRITORIES TO TOTAL VALUE OF MINERAL PRODUCTION, 1974-80

	1974	1975	1976	1977	1978	1979	1980P
Alberta	38.4	43.1	44.2	46.4	49.8	49.5	52.0
Ontario	20.7	17.6	17.3	16.1	13.3	12.5	14.4
British Columbia	9.8	9.7	10.2	9.1	9.3	10.3	8.6
Quebec	10.4	9.2	9.5	9.1	8.9	8.3	7.7
Saskatchewan	6.7	6.5	6.2	6.5	7.8	7.2	7.1
Newfoundland	3.8	4.1	4.7	4.7	3.3	4.3	3.3
Manitoba	4.2	4.0	3.3	3.1	2.3	2.5	2.6
New Brunswick	1.9	1.7	1.5	1.6	1.7	1.8	1.2
Northwest Territories	1.9	1.6	1.5	1.4	1.5	1.7	1.2
Yukon	1.5	1.7	0.8	1.1	1.1	1.1	0.9
Nova Scotia	0.7	0.8	0.8	0.9	1.0	0.8	0.8
Prince Edward Island	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

P Preliminary.

TABLE 8. CANADA'S WORLD ROLE AS A PRODUCER OF

		World
Potash (K_2O equivalent)	000 t	25 933
	% of world total	
Zinc (mine production)	000 t	6 342
	% of world total	
Asbestos	000 t	4 899
	% of world total	
Sulphur, elemental	000 t	35 059
	% of world total	
Uranium (U concentrates)	t	44 465
	% of world total	
Nickel (mine production)	t	681 100
	% of world total	
Gypsum	000 t	74 348
	% of world total	
Molybdenum	t	104 047
	% of world total	
Gold (mine production)	kg	1 206 491
	% of world total	
Platinum group metals (mine production)	kg	201 746
	% of world total	
Lead (mine production)	t	3 283 000
	% of world total	
Titanium concentrates (ilmenite)	000 t	5 001
	% of world total	
Copper (mine production)	t	7 916 900
	% of world total	
Cadmium (smelter production)	t	18 374
	% of world total	
Aluminum (primary metal)	t	15 127 600
	% of world total	
Silver	kg	10 008 000
	% of world total	
Iron ore	000 t	848 500
	% of world total	

P Preliminary; e Estimated.

CERTAIN IMPORTANT MINERALS, 1979P

Rank of Six Leading Countries 1	2	3	4	5	6
Canada 7 066 27.2	U.S.S.R. 6 635 25.6	East Germany 3 395 13.1	West Germany 2 690 10.4	U.S.A. 2 225 8.6	France 1 920 7.4
Canada 1 207 19.0	U.S.S.R. 1 020^e 16.1	Australia 532 8.4	Peru 491 7.7	U.S.A. 294 4.6	Mexico 246 3.9
U.S.S.R. 2 020^e 41.2	**Canada** 1 501 30.6	Zimbabwe 260 5.3	People's Republic of China 250^e 5.1	Republic of South Africa 249 5.1	Italy 144 2.9
U.S.A. 9 770 27.9	**Canada** 6 718 19.2	Poland 4 850 13.8	U.S.S.R. 3 800 10.8	Mexico 2 120 6.1	France 1 992 5.7
U.S.A. 16 904 38.2	**Canada** 7 698 17.3	Republic of South Africa 5 637 12.7	Namibia 4 960 11.2	Niger 3 760 8.4	France 2 785 6.3
U.S.S.R. 150 000^e 22.0	**Canada** 118 100 17.3	New Caledonia 82 900 12.2	Australia 69 700 10.2	Indonesia 37 200 5.5	Cuba 35 000 5.1
U.S.A. 13 272 17.9	**Canada** 8 105 10.9	Iran 6 350 8.5	France 5 897 7.9	U.S.S.R. 5 445^e 7.3	Spain 4 536 6.1
U.S.A. 65 302 62.8	Chile 15 559 15.0	**Canada** 11 175 10.7	U.S.S.R. 10 205^3 9.8	People's Republic of China 1 995^e 1.9	Peru 1 182 1.1
Republic of South Africa 703 467 58.2	U.S.S.R. 253 805^e 21.0	**Canada** 51 143 4.2	U.S.A. 30 167 2.5	Papua New Guinea 19 611 1.6	Australia 18 566 1.5
U.S.S.R. 99 530^e 49.3	Republic of South Africa 98 840^e 9.0	**Canada** 6 156 3.1	Columbia 402 0.2	Australia 309^e 0.2	U.S.A. 247 0.1
U.S.S.R. 600 000^e 18.3	U.S.A. 532 000 16.2	Australia 405 000 12.3	**Canada** 341 000 10.4	Peru 184 000 5.6	Mexico 161 000 4.9
Australia 1 163 22.9	Norway 810 16.2	U.S.A. 590 11.6	**Canada** 477 9.5	U.S.S.R. 408 8.2	Malaysia 187 3.7
U.S.A. 1 441 300 18.2	U.S.S.R. 1 140 000^e 14.4	Chile 1 060 600 13.4	**Canada** 643 800 8.1	Zambia 588 300 7.4	Zaire 399 800 5.0
U.S.S.R. 2 900^e 15.8	Japan 2 594 14.1	U.S.A. 2 057 11.2	**Canada** 1 460 7.9	Belgium 1 409 7.7	West Germany 1 183 6.4
U.S.A. 4 556 800 30.1	U.S.S.R. 2 400 000^e 15.9	Japan 1 010 400 6.7	**Canada** 860 300 5.7	West Germany 741 900 4.9	Norway 673 500 4.5
Mexico 1 533 712 14.2	U.S.S.R. 1 430 000^e 13.2	Peru 1 350 357 12.5	U.S.A. 1 183 642 11.0	**Canada** 1 146 909 10.6	Australia 828 996 7.7
U.S.S.R. 246 000 29.0	U.S.A. 86 340 10.2	Australia 84 180 9.9	People's Republic of China 70 000 8.2	**Canada** 58 500 6.9	Brazil 48 750 5.7

TABLE 9. CANADA, CENSUS VALUE ADDED, COMMODITY-PRODUCING INDUSTRIES, 1973-79

	1973	1974	1975	1976	1977	1978	1979P
				($ million)			
Primary industries							
Agriculture	4,601	5,709	6,122	5,864	5,606	6,873	7,957
Forestry	1,109	1,244	1,126	1,348	1,440	1,647	2,053
Fishing	322	293	294	394	491	705	888
Hunting and trapping	29	26	26	38	44	59	80
Mining[1]	6,289	8,930	9,750	11,361	13,247	15,016	19,820
Electrical power	2,145	2,514	2,774	3,421	4,346r	5,280	6,012
Total	14,495	18,716	20,092	22,425	25,173	29,580	36,809
Secondary industries							
Manufacturing	30,767	37,655	38,684	42,553	46,801	54,635	64,354
Construction	9,695	11,850	13,718	12,270	18,275	19,648	21,988
Total	40,462	49,505	52,401	59,824	65,076	74,282	86,342
Grand total	54,957	68,221	72,493	82,249	90,249	103,862	123,151

[1] Cement, lime, clay and clay products (from domestic clays) industries are included under "Manufacturing".

P Preliminary; r Revised.

TABLE 10. CANADA, CENSUS VALUE ADDED, TOTAL ACTIVITY, MINING AND MINERAL MANUFACTURING INDUSTRIES, 1973-79

	1973	1974	1975	1976	1977	1978	1979
				($000)			
Mining							
Metallic minerals							
Gold-quartz	119.2	163.6	149.9	113.7	152.0	207.6	322.8
Copper-gold-silver	1,026.5	1,028.6	595.4	600.7	571.3	715.9	1,434.5
Silver-lead-zinc	292.7	328.3	320.8	233.7	279.8	372.7	671.9
Nickel-copper	820.3	1,049.7	729.7	888.1	673.0	572.6	1,035.1
Iron	345.8	403.9	556.7	732.1	807.3	717.0	1,022.2
Uranium	69.2	93.3	157.8	195.8	300.1	501.7	525.4
Miscellaneous metal mines	37.5	50.0	53.7	74.2	118.0	138.6	179.7
Total	2,711.3	3,171.4	2,563.9	2,838.4	2,901.4	3,226.1	5,191.6
Industrial minerals							
Asbestos	176.4	239.8	230.6	373.2	474.8	401.6	456.8
Gypsum	16.7	16.5	14.9	15.8	21.0	25.9	27.5
Peat	14.2	19.8	20.6	23.7	27.4	33.7	38.8
Potash	129.0	232.7	298.5	262.1	301.4	360.2	613.5
Salt	36.7	49.8	45.9	70.7	70.9	77.9	86.4
Sand and gravel	59.8	83.5	102.3	99.0	91.3	85.8	91.5
Stone	67.0	92.9	111.0	111.0	106.1	110.2	121.7
Miscellaneous nonmetals	27.9	37.5	40.4	42.4	45.6	44.7	53.7
Total	527.6	772.4	864.1	997.8	1,138.4	1,139.9	1,489.8
Fuels							
Coal	166.7	261.2	483.5	474.3	508.5	566.8	658.6
Petroleum and natural gas	2,883.3	4,725.0	5,838.5	7,050.0	8,698.3	10,083.4	12,559.7
Total	3,050.0	4,986.2	6,322.0	7,524.3	9,206.9	10,650.2	13,218.2
Total mining industry	6,288.9	8,930.0	9,750.0	11,360.5	13,246.7	15,016.2	19,899.6
Mineral manufacturing							
Primary metal industries							
Iron and steel mills	1,169.6	1,398.7	1,364.0	1,498.8	1,677.6	1,924.9	2,424.3
Steel pipe & tube mills	115.6	152.3	170.3	148.8	160.3	225.1	280.4
Iron foundries	163.7	222.4	238.1	241.9	257.7	273.8	298.2
Smelting and refining	590.7	794.2	886.4	812.7	1,176.1	1,387.2	1,401.0
Aluminum rolling, casting and extruding	94.6	146.7	132.6	149.4	193.7	154.3	249.0
Copper and alloy rolling, casting and extruding	91.0	91.3	68.3	71.4	78.5	93.1	131.5
Metal rolling, casting and extruding, nes	83.6	106.1	88.4	113.3	110.2	136.2	198.9
Total	2,308.9	911.8	948.2	3,036.3	3,654.0	4,194.7	4,983.3

(continued on following page)

TABLE 10. (cont'd)

	1973	1974	1975	1976	1977	1978	1979
				($000)			
Mineral manufacturing (cont'd)							
Nonmetallic mineral products industries							
Cement manufacturers	172.2	190.4	210.3	249.1	275.0	319.9	388.8
Lime manufacturers	17.9	25.0	24.9	30.0	36.6	44.6	49.3
Concrete products manufacturers	197.7	248.5	282.1	282.1	273.5	309.3	328.7
Ready-mix concrete manufacturers	202.1	236.3	282.6	282.6	292.8	317.3	341.6
Clay products (domestic clay)	41.6	51.5	59.7	65.9	69.6	73.6	87.5
Clay products (imported clay)	33.8	41.7	41.7	39.1	39.8	43.1	44.9
Refractories manufacturers	28.1	37.2	45.8	44.4	32.5	45.3	66.6
Stone products manufacturers	11.0	12.3	14.0	16.3	19.6	22.4	28.2
Glass manufacturers	162.4	190.0	185.6	205.1	199.2	266.8	294.9
Glass products manufacturers	73.3	72.4	74.3	87.4	96.6	122.9	141.0
Abrasive manufacturers	38.0	46.0	43.9	55.1	64.1	70.6	79.4
Other nonmetallic mineral products industries	171.6	195.2	237.4	270.2	253.6	341.0	375.2
Total	1,149.8	1,346.6	1,502.4	1,627.3	1,652.9	1,976.8	2,226.2
Petroleum and coal products industries							
Petroleum refining	539.6	925.2	789.7	945.8	1,206.7	1,180.4	1,390.9
Manufacturers of lubricating oil and greases	22.4	26.3	32.6	32.6	36.8	36.9	38.3
Other petroleum and coal products industries	18.7	26.7	43.6	45.7	44.4	33.1	30.5
Total	580.7	978.3	866.0	1,024.2	1,287.9	1,250.4	1,459.8
Total mineral manufacturing	4,039.4	5,236.6	5,316.5	5,687.8	6,594.8	7,421.9	8,669.2
Total mining and mineral manufacturing	10,328.3	14,166.6	15,066.6	17,048.3	19,841.5	22,438.1	28,568.9

(1) Included with "Miscellaneous nonmetals".
P Preliminary; nes Not elsewhere specified.

TABLE 11. CANADA, INDEXES OF PHYSICAL VOLUME OF TOTAL INDUSTRIAL PRODUCTION, MINING AND MINERAL MANUFACTURING, 1966-1980 (1971=100)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980P
Total industrial production	79.2	82.3	87.6	93.6	94.9	100.0	107.5	118.1	122.2	114.9	121.3	125.2	132.4	135.0	132.8
Total mining	74.1	79.9	86.2	86.9	98.7	100.0	106.5	119.3	117.3	107.1	109.8	114.0	105.3	116.3	118.3
Metals															
All metals	81.5	89.9	95.5	88.4	105.4	100.0	96.1	107.5	106.0	97.7	103.2	105.9	85.1	89.7	94.3
Placer gold and gold quartz mines	150.0	134.1	121.7	118.2	105.3	100.0	90.0	78.7	66.9	67.2	69.3	67.5	64.8	58.1	54.6
Iron mines	82.7	88.8	104.8	91.9	116.1	100.0	83.3	102.6	92.1	88.5	119.6	113.1r	81.0r	119.4	104.0
Other metal mines	76.5	87.8	92.0	85.3	103.0	100.0	99.6	110.1	111.4	101.4	100.7	105.4	86.7	83.9	93.8
Fuels															
All fuels	61.3	67.1	73.4	80.8	92.6	100.0	118.5	134.1	128.2	118.6	110.9	113.7	113.6	125.8	122.5
Coal	70.7	70.3	68.7	68.4	87.5	100.0	148.2	158.6	159.1	200.6	184.9	203.4	226.8	240.9	262.3
Crude oil and natural gas	60.7	66.8	73.7	81.7	93.0	100.0	116.1	132.1	125.7	111.9	104.8	106.3	104.7r	116.4	111.0
Nonmetals															
All nonmetals	71.8	76.8	83.7	92.8	95.0	100.0	99.4	107.9	123.6	102.8	115.5	127.4	120.6	131.7	135.0
Asbestos	79.5	78.9	82.6	89.8	95.2	100.0	99.0	103.4	108.2	70.1	99.2	103.5r	86.3r	94.3	89.3
Mineral manufacturing															
Primary metals	87.9	84.5	92.9	94.9	100.9	100.0	101.7	113.2	122.6	109.9	107.7	116.1	123.7	123.9	127.7
Nonmetallic mineral products	86.0	80.7	87.1	90.5	86.6	100.0	107.7	117.6	123.3	116.5	118.5	121.5	133.7	122.4	112.9
Petroleum and coal products	79.2	79.9	88.7	92.1	94.4	100.0	112.8	128.8	132.5	130.8	129.2	135.0	136.7	142.7	141.9

P Preliminary; r Revised.

TABLE 12. CANADA, INDEXES OF REAL DOMESTIC PRODUCT BY INDUSTRIES, 1966-80 (1971=100)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980P
Real domestic product, all industries	79.5	82.3	86.9	92.2	94.4	100.0	105.5	113.6	119.0	119.8	126.1	130.1	135.3	138.5	138.8
Agriculture	96.7	78.9	85.2	90.6	89.0	100.0	88.5	93.7	89.8	98.0	104.2	108.8	117.8	108.1	109.1
Forestry	88.3	90.1	94.4	102.4	103.3	100.0	102.4	123.9	117.8	97.6	112.3	116.4	123.8	123.3	119.5
Fishing and trapping	107.5	102.0	115.6	102.6	105.4	100.0	95.5	100.4	89.3	88.3	102.1	106.9	126.5	132.4	121.9
Mining (incl. milling), quarries and oil wells	74.1	79.9	86.2	86.9	98.7	100.0	106.5	119.3	117.3	107.1	109.8	114.0	105.3	116.3	118.3
Electric power, gas and water utilities	67.9	72.6	78.2	85.4	93.3	100.0	111.4	120.7	130.2	130.7	142.9	151.0	159.7	168.7	173.4
Manufacturing	81.5	83.9	89.1	95.8	94.5	100.0	107.1	117.6	122.0	114.3	120.8	124.1	133.8	134.2	130.6
Construction	88.5	87.1	90.1	92.5	90.9	100.0	102.4	107.5	112.6	116.7	122.8	121.8	120.7	123.2	124.8
Transportation, storage and communications	73.1	77.9	82.8	89.0	94.2	100.0	107.0	116.3	124.0	126.9	133.7	139.5	145.2	156.5	159.2
Trade	80.2	83.7	87.1	91.7	93.2	100.0	109.2	118.9	128.0	128.8	135.1	136.5	140.9	144.6	141.7
Community, business and personal service	75.0	81.4	85.7	91.6	95.5	100.0	104.2	108.8	115.0	119.9	125.7	129.9	134.0	137.7	139.2
Finance, insurance and real estate	78.8	81.7	86.7	92.4	94.6	100.0	106.0	114.7	120.6	127.8	135.6	143.7	150.5	153.4	159.3
Public administration and defence	82.7	86.8	89.1	91.6	95.2	100.0	104.3	109.8	114.0	119.6	123.0	126.1	128.8	128.6	128.8

P Preliminary.

TABLE 13. CANADA, VALUE OF EXPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS, BY MAIN GROUPS, 1974-80

	1974	1975	1976	1977	1978	1979[P]	1980[e]
				($ million)			
Ferrous							
Crude material	573.9	721.5	984.4	1,114.9	854.5	1,469.5	1,341.9
Fabricated material	917.8	913.1	1,007.4	1,242.9	1,696.0	1,948.2	2,355.4
Total	1,491.7	1,634.7	1,991.8	2,357.9	2,550.6	3,417.8	3,697.3
Nonferrous							
Crude material	1,801.8	1,519.6	1,528.0	1,614.9	1,549.2	2,419.4	2,873.3
Fabricated material	2,102.7	1,843.5	2,231.3	2,578.4	3,360.9	3,805.3	6,271.4
Total	3,904.6	3,363.1	3,759.3	4,193.4	4,910.1	6,224.7	9,144.6
Nonmetals							
Crude material	799.0	794.9	1,103.4	1,276.1	1,369.7	1,715.3	2,297.5
Fabricated material	178.4	162.7	194.7	253.6	377.2	484.0	411.6
Total	977.4	957.6	1,298.1	1,529.6	1,746.8	2,199.4	2,709.1
Mineral fuels							
Crude material	4,232.6	4,637.3	4,464.0	4,428.9	4,514.9	6,128.9	7,816.8
Fabricated material	611.3	638.5	562.0	649.1	1,022.7	1,883.7	2,324.2
Total	4,843.9	5,275.8	5,026.0	5,078.0	5,537.6	8,012.6	10,141.0
Total minerals and products							
Crude material	7,407.4	7,673.3	8,079.8	8,434.9	8,288.2	11,733.1	14,329.4
Fabricated material	3,810.1	3,557.8	3,995.5	4,724.1	6,456.8	8,121.3	11,362.5
Total	11,217.5	11,231.1	12,075.3	13,158.9	14,745.0	19,854.5	25,692.0

[P] Preliminary; [e] Estimated.

TABLE 14. CANADA, VALUE OF IMPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS, BY MAIN GROUPS, 1974-80

	1974	1975	1976	1977	1978	1979[P]	1980[e]
				($ million)			
Ferrous							
Crude material	94.6	179.5	129.8	106.0	223.8	322.1	356.1
Fabricated material	1,759.8	1,494.7	1,274.0	1,501.0	1,838.3	2,530.8	2,346.0
Total	1,854.4	1,674.2	1,403.8	1,607.0	2,062.1	2,852.9	2,702.1
Nonferrous							
Crude material	302.6	288.9	294.6	409.0	480.9	765.9	1,768.9
Fabricated material	816.3	621.8	600.4	662.1	949.1	2,165.0	2,771.6
Total	1,118.9	910.7	895.0	1,071.1	1,430.0	2,930.9	4,540.5
Nonmetals							
Crude material	121.0	183.0	157.9	170.6	231.0	277.6	329.2
Fabricated material	326.0	358.7	413.5	472.0	526.8	653.5	725.4
Total	447.1	541.7	571.4	642.6	757.8	931.1	1,054.7
Mineral fuels							
Crude material	2,955.5	3,886.8	3,834.1	3,876.4	4,092.8	5,374.2	7,732.3
Fabricated material	373.6	275.8	219.7	299.7	344.8	389.6	687.7
Total	3,329.1	4,162.6	4,053.8	4,176.1	4,437.6	5,763.8	8,420.0
Total minerals and products							
Crude material	3,473.8	4,538.2	4,416.4	4,562.0	5,028.6	6,739.8	10,186.6
Fabricated material	3,275.7	2,751.0	2,507.6	2,934.8	3,659.0	5,738.9	6,530.7
Total	6,749.5	7,289.2	6,924.0	7,496.8	8,687.6	12,478.7	16,717.3

[P] Preliminary; [e] Estimate.

TABLE 15. CANADA, VALUE OF EXPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS IN RELATION TO TOTAL EXPORT TRADE, 1970, 1975, 1980

	1970		1975		1980^e	
		%		%		%
Crude material	2,840.5	17.2	7,673.3	23.6	14,329.4	19.3
Fabricated material	2,361.9	14.3	3,557.8	10.9	11,362.5	15.3
Total	5,202.4	31.5	11,231.1	34.5	25,692.0	34.6
Total exports, all products	16,491.1	100.0	32,586.9	100.0	74,259.3	100.0

e Estimated.

TABLE 16. CANADA, VALUE OF IMPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS IN RELATION TO TOTAL EXPORT TRADE, 1970, 1975, 1980

	1970		1975		1980^e	
		%		%		%
Crude material	878.4	6.3	4,538.2	13.0	10,186.6	14.7
Fabricated material	1,367.5	9.8	2,751.0	7.9	6,530.7	9.4
Total	2,245.9	16.1	7,289.2	20.9	16,717.3	24.2
Total exports, all products	13,939.4	100.0	34,829.7	100.0	69,127.7	100.0

e Estimated.

TABLE 17. CANADA, VALUE OF EXPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS, BY MAIN GROUPS AND DESTINATION, 1980P

	U.S.A.	United Kingdom	E.F.T.A.[1]	E.E.C.[2]	Japan	Other countries	Total
				($ million)			
Ferrous materials and products	2,410.2	152.9	17.8	492.3	113.0	511.0	3,697.3
Nonferrous materials and products	4,812.7	1,018.4	422.6	1,023.6	1,002.1	865.2	9,144.6
Nonmetallic mineral materials and products	1,195.6	68.6	26.1	310.5	130.8	977.4	2,709.1
Mineral fuels, materials and products	8,565.4	3.1	103.8	380.8	649.9	438.0	10,141.0
Total	16,983.9	1,243.0	570.4	2,207.2	1,895.8	2,791.6	25,692.0
Percentage of total mineral exports	66.1	4.8	2.2	8.6	7.4	10.7	100.0

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[1] European Free Trade Association includes Austria, Norway, Portugal, Sweden, Switzerland, Finland and Iceland. [2] European Economic Community includes Belgium-Luxembourg, France, Italy, Netherlands, West Germany, Denmark and Ireland.
P Preliminary.

TABLE 18. CANADA, VALUE OF IMPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS, BY MAIN GROUPS AND DESTINATION, 1980P

	U.S.A.	United Kingdom	E.F.T.A.[1]	E.E.C.[2]	Japan	Other countries	Total
				($ million)			
Ferrous materials and products	1,805.5	131.6	79.5	189.9	300.2	196.5	2,702.1
Nonferrous materials and products	3,482.1	44.4	205.9	58.4	53.6	696.2	4,540.5
Nonmetallic mineral materials and products	763.2	31.4	10.3	107.2	31.1	111.5	1,054.7
Mineral fuels, materials and products	2,804.6	84.9	-	34.7	-	5,495.8	8,420.0
Total	8,854.2	292.3	295.8	390.1	384.8	6,500.0	16,717.3
Percentage of total mineral exports	53.0	1.7	1.8	2.3	2.3	38.9	100.0

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[1] European Free Trade Association includes Austria, Norway, Portugal, Sweden, Switzerland, Finland and Iceland. [2] European Economic Community includes Belgium-Luxembourg, France, Italy, Netherlands, West Germany, Denmark and Ireland.
P Preliminary; - Nil.

TABLE 19. CANADA, VALUE OF EXPORTS OF CRUDE MINERALS AND FABRICATED MINERAL PRODUCTS, BY COMMODITY AND DESTINATION, 1980P

	United States	United Kingdom	E.F.T.A.[1]	E.E.C.[2]	Japan	Other Countries	Total
				($ 000)			
Aluminum	923,665	21,683	23,600	116,347	240,642	530,331	1,856,268
Asbestos	132,107	50,049	24,142	175,928	53,045	228,986	664,257
Copper	473,902	198,350	82,870	292,053	355,539	194,127	1,596,841
Fuels	8,565,387	3,090	103,840	380,785	649,851	438,003	10,140,956
Iron ore	666,180	124,374	7,049	339,342	81,154	22,065	1,240,164
Lead	45,695	38,529	5,647	65,115	70,442	31,144	256,572
Molybdenum	12,101	50,595	830	174,361	113,468	8,239	359,594
Nickel	541,393	199,438	240,032	157,334	32,417	94,489	1,265,103
Primary ferrous metals	167,835	4,571	806	87,517	25,612	95,495	381,836
Uranium	209,978	10,319	-	1	8,035	2,329	230,662
Zinc	293,809	47,965	8,355	103,572	34,160	107,405	595,266
All other minerals	4,951,860	494,131	73,232	314,646	231,431	1,038,950	7,104,450
Total	16,983,912	1,243,094	570,403	2,207,201	1,895,796	2,791,563	25,691,969

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[1] European Free Trade Association includes Austria, Norway, Portugal, Sweden, Switzerland, Finland and Iceland. [2] European Economic Community includes Belgium-Luxembourg, France, Italy, Netherlands, West Germany, Denmark and Ireland.
P Preliminary; - Nil.

TABLE 20. CANADA, PHYSICAL VOLUME OF IMPORT TRADE FOR SELECTED COMMODITIES, 1974-80

	Units of Weight	1974	1975	1976	1977	1978	1979	1980P
Crude materials								
Metals								
Aluminum ore	tonnes	883 566	760 616	908 055	821 596	1 056 190	952 584	983 972
Bauxite ore	tonnes	2 715 604	2 420 669	1 230 052	2 764 286	2 434 435	2 149 636	3 504 368
Iron ore	tonnes	2 333 194	4 844 416	3 020 130	2 505 203	4 685 868	5 912 581	5 875 292
Manganese ore	tonnes	125 103	69 773	118 972	57 644	136 446	45 150	95 161
Nonmetals								
Bentonite	tonnes	263 529	242 183	274 095	358 724	353 790	638 307	471 684
Clay, ground & unground	tonnes	327 493	328 987	355 760	334 431	381 486	445 231	403 246
Fluorspar	tonnes	142 246	157 222	137 310	124 494	170 237	167 904	223 940
Limestone, crushed	tonnes	2 525 190	3 281 800	3 513 824	2 922 684	2 873 601	3 215 717	2 418 330
Phosphate rock	tonnes	3 366 338	3 282 257	2 241 086	2 439 021	3 043 899	3 341 039	3 816 514
Salt & Brine	tonnes	736 573	1 183 144	1 523 407	1 126 225	1 330 474	1 275 627	1 151 203
Sand & Gravel	tonnes	1 572 904	1 909 894	2 085 922	1 645 663	1 810 989	1 201 915	1 209 582
Silica sand	tonnes	955 934	1 044 160	1 337 139	1 101 186	1 242 444	1 651 890	1 200 237
Fuels								
Coal	tonnes	12 167 679	14 962 896	14 371 622	15 026 358	13 000 320	17 381 794	15 719 025
Petroleum, crude	metres^3	1 323 457	1 356 653	1 258 913	1 087 777	1 050 929	1 010 226	935 296
Fabricated materials								
Metals								
Aluminum & Aluminum alloy	tonnes	156 061	79 726	115 870	118 216	119 154	168 125	128 061
Ferroalloys	tonnes	84 863	117 920	95 272	93 672	101 160	167 232	118 516
Steel:								
bars & rods	tonnes	774 716	382 990	307 057	301 502	318 336	299 801	189 903
castings & forgings	tonnes	134 370	108 826	123 609	113 365	116 473	139 095	129 363
pipes & tubes	tonnes	250 206	196 138	169 916	203 238	317 031	285 144	323 009
sheets & strips	tonnes	1 323 172	582 573	466 172	552 606	704 502	1 039 054	582 215
structural shapes	tonnes	594 210	190 655	231 619	225 869	151 502	273 111	207 639
Nonmetals								
Cement	tonnes	262 444	428 777	329 045	263 528	256 721	248 421	223 247
Fire bricks	tonnes	293 628	229 664	189 599	242 720	156 002	227 156	236 205
Magnesia & dolomite	tonnes	50 820	89 800	45 689	56 189	68 214	92 824	80 916
Phosphate fertilizers	tonnes	93 026	128 045	168 482	200 445	286 744	381 887	248 381
Fuels								
Coke	tonnes	1 255 091	1 119 013	876 943	1 267 895	1 527 342	1 366 182	1 311 698
Fuel oil	metres^3	3 387 520	1 335 056	1 137 041	1 260 034	1 277 077	871 424	1 617 606

P Preliminary.

TABLE 21. CANADA, PHYSICAL VOLUME OF EXPORT TRADE FOR SELECTED COMMODITIES, 1974-80

	Unit of Weight	1974	1975	1976	1977	1978	1979	1980P
Crude materials								
Metals								
Copper, ores & concentrates	tonnes	344 271	314 518	294 823	279 582	282 159	315 211	286 076
Iron, ores & concentrates	tonnes	37 447 869	36 059 820	44 684 868	45 060 391	31 929 094	48 849 270	39 020 922
Lead, ores & concentrates	tonnes	194 089	211 909	140 933	137 820	142 693	151 485	147 007
Zinc, ores & concentrates	tonnes	866 698	705 089	653 737	598 451	688 186	598 279	434 177
Nonmetals								
Asbestos, crude & fibers	tonnes	1 652 542	1 085 598	1 502 435	1 415 482	1 398 081	1 461 041	1 216 929
Crude refractory materials	tonnes	1 075 565	536 208	820 645	747 938	1 081 684	1 023 733	803 892
Gypsum	tonnes	5 212 430	3 691 676	3 798 243	4 994 323	5 178 631	5 474 764	4 960 240
Limestone, crushed	tonnes	1 219 172	1 217 564	1 287 976	1 502 492	1 710 348	2 296 295	2 214 489
Nepheline syenite	tonnes	454 699	356 629	418 975	443 763	420 961	471 056	448 468
Salt and Brine	tonnes	-	-	1 423 847	1 163 163	1 608 582	1 822 120	1 637 600
Sand and Gravel	tonnes	357 090	138 452	377 677	273 745	269 216	323 639	383 533
Sulphur, crude or refined	tonnes	4 251 487	3 284 246	3 719 992	4 291 032	4 984 545	5 154 831	6 850 142
Fuels								
Coal	tonnes	10 774 106	11 694 655	11 761 930	12 068 905	13 657 514	13 852 847	14 310 782
Natural gas	million metres^3	27 204 368	26 885 865	27 015 710	28 141 415	24 992 242	28 047 648	22 963 134
Fabricated materials								
Metals								
Aluminum, pig ingots	tonnes	689 877	512 050	510 751	655 353	863 320	551 957	784 720
Copper, refinery shapes	tonnes	288 335	320 705	322 991	294 490	247 727	191 211	335 022
Iron, pig ingots	tonnes	517 441	406 308	281 577	505 277	544 716	255 523	562 351
Lead, pig ingots	tonnes	76 027	110 882	114 421	130 819	131 950	117 992	126 538
Zinc, pig ingots	tonnes	296 777	247 474	352 071	295 358	439 260	429 352	471 949
Nonmetals								
Abrasives	tonnes	276 059	206 274	240 458	240 307	274 695	267 560	238 740
Cement	tonnes	1 148 393	934 981	921 031	1 274 652	1 634 582	2 288 822	1 527 482
Lime, quick & hydrated	tonnes	386 650	234 034	309 355	359 540	478 551	490 863	403 165
Fuels								
Butane gas, liquified	metres^3	2 536 282	2 356 672	2 792 650	2 432 188	2 208 682	2 926 459	2 563 406
Coke	tonnes	285 832	257 657	321 636	355 919	217 596	228 601	319 554
Fuel Oil	metres^3	5 521 888	3 781 202	2 092 266	1 456 991	4 232 409	4 654 162	4 273 510
Gasoline	metres^3	265 880	775 240	439 222	388 080	972 282	913 271	706 539
Propane gas, liquified	metres^3	3 073 855	3 512 927	4 048 280	5 019 524	3 543 782	4 858 175	3 879 915

P Preliminary; - Not available.

TABLE 22. CANADA, APPARENT CONSUMPTION[1] OF SOME MINERALS, AND RELATION TO PRODUCTION[2], 1978-80P

	Unit of Measure	1978			1979			1980P		
		Apparent Consumption	Production	Consumption as % of production	Apparent Consumption	Production	Consumption as % of production	Apparent Consumption	Production	Consumption as % of production
Asbestos	t	24 491	1 421 808	1.7	34 154	1 493 000	2.3	119 602	1 335 000	9.0
Cement	t	9 180 418[r]	10 558 279	87.0	9 724 878	11 765 000	82.7	9 102 080	10 497 000	86.7
Gypsum	t	2 966 805	8 074 441	36.7	2 776 137	8 908 000	34.3	2 403 874	7 209 000	33.4
Iron ore	t	15 687 577	42 930 803	36.5	17 587 048	59 617 000	29.5	17 720 218	50 866 000	34.8
Lime	t	1 586 789	2 034 211	78.0	1 409 439	1 859 000	75.8	1 700 673	2 063 000	82.4
Quartz silica	t	3 341 674	2 165 050	154.3	3 508 425	2 368 000	148.2	4 212 582	2 624 000	160.5
Salt	t	6 173 785	6 451 894	95.7	6 334 503	6 881 000	92.1	6 542 469	7 029 000	93.1

[1] "Apparent consumption" is production, plus imports, less exports. [2] "Production" refers to producers' shipments.
P Preliminary; [r] Revised.

TABLE 23. CANADA, REPORTED CONSUMPTION OF MINERALS AND RELATION TO PRODUCTION, 1978-80

	Unit of Measure	1978			1979			1980[P]		
		Consumption	Production	Consumption as % of production	Consumption	Production	Consumption as % of production	Consumption	Production	Consumption as % of production
Metals										
Aluminum	t	380 291	1 048 469	36.3	399 049	860 287	46.4	329 371	1 068 197	30.8
Antimony	kg	345 282[r]	..	..	463 423[r]	..	..	369 732	..	..
Bismuth	kg	25 664	145 104	17.7	25 117	136 733	18.4	10 271	149 366	6.9
Cadmium	kg	47 523	1 151 298	4.1	48 746	209 459	4.0	49 868	1 033 097	4.8
Chromium (chromite)	t	27 472	–	..	27 205	–	..	27 900	–	..
Cobalt	kg	144 610	1 233 777	11.7	114 606	1 639 624	7.0	105 225	2 118 154	5.0
Copper	t	228 694[1]	659 380	34.7	210 689[1]	636 383	33.1	195 124[1]	716 363	27.2
Lead	t	100 762[2]	319 809	31.5	126 464[2]	310 745	40.7	124 813[2]	251 627	49.6
Magnesium	t	3 953	8 309	47.6	4 450	9 015	49.4	5 412	9 252	58.5
Manganese ore	t	201 320	–	..	61 643	–	..	159 243	–	..
Mercury	kg	29 904	–	..	26 249	–	..	36 326	–	..
Molybdenum (Mo content)	kg	1 269	13 943	9.1	1 250	11 175	11.2	1 055	11 889	8.9
Nickel	t	11 790	128 310	9.2	8 336	126 482	6.6	9 676	184 802	5.2
Selenium	kg	14 364	122 405	11.7	15 773	217 759	7.2	10 795	279 626	3.9
Silver	kg	329 320	1 266 927	2.6	251 985	1 146 908	22.0	67 122	1 069 635	6.3
Tellurium	kg	..	31 421	..	..	42 433	..	..	15 011	..
Tin	t	4 922	360	1 367.2	4 675	338	1 383.1	4 507	243	1 854.7
Tungsten (W content)	kg	388 146	2 885 619	13.5	380 229	3 254 067	11.7	290 479	4 006 647	7.3
Zinc	t	121 375	1 066 902	11.4	131 317	1 099 926	11.9	107 879	883 697	12.2
Nonmetals										
Barite	t	58 123	99 339	58.5	79 595	73 512	108.3	142 421	94 317	151.0
Feldspar	t	4 586	–	..	4 588[r]	–	..	4 051	–	..
Fluorspar	t	128 280	–	..	107 004	–	..	131 262	–	..
Mica	kg	3 793[r]	..	..	2 208[r]	–	..	2 576	..	..
Nepheline syenite	t	88 806	599 121	14.8	86 788[r]	605 699	14.3	84 873	599 699	14.2
Phosphate rock	t	3 029 600[r]	–	..	3 203 400[r]	–	..	3 546 636	–	..
Potash (K_2O)	t	..	6 344 010	..	..	7 074 388	..	..	7 201 217	..
Sodium sulphate	t	227 766	376 563	60.5	255 050	443 279	57.5	232 045	480 666	48.3
Sulphur	t	799 709	5 752 208	13.9	976 730[r]	6 314 144	15.5	817 362	7 655 723	10.7
Talc, etc.	t	43 119	61 661	69.9	46 940	90 330	52.0	42 217	91 848	44.0
Fuels										
Coal	t	31 738	30 478	104.1	34 764	33 200	104.7	37 333	36 688	101.8
Natural gas	000 m^3	42 543[r][3]	80 609	52.8	44 156[r][3]	94 426	46.8	44 820[3]	87 108	51.5
Crude oil	m^3	105 485[r][4]	76 348	138.2	113 150[r][4]	86 910	130.2	109 865[4]	83 477	131.6

Note: Unless otherwise stated, consumption refers to reported consumption of refined metals or nonmetallic minerals by consumers. Production of metals, in most cases, refers to production in all forms, and includes the recoverable content of ores, concentrates, matte, etc., and metal content of primary products recoverable at domestic smelters and refineries. Production of nonmetals refers to producers' shipments. For fuels, production is equivalent to actual output less waste.

[1] Producers domestic shipments of refined metal. [2] Includes primary and secondary refined metal. [3] Domestic sales. [4] Refinery receipts.

[P] Preliminary; – Nil; .. Not available or not applicable; [r] Revised.

TABLE 24. CANADA, DOMESTIC CONSUMPTION OF PRINCIPAL REFINED METALS IN RELATION TO REFINERY PRODUCTION[1], 1974-80

	Unit of Measure	1974	1975	1976	1977	1978	1979	1980
Copper								
Domestic consumption[2]	tonnes	247 985	185 194	206 205	200 372	228 694	210 689	195 124
Production	tonnes	559 125	529 199	510 469	508 767	446 278	397 263	505 238
Consumption of production	%	44.4	35.0	40.4	39.4	51.2	53.0	38.6
Zinc								
Domestic consumption[3]	tonnes	117 619	98 280	98 897	105 412	121 375	131 317	107 879
Production	tonnes	437 725	426 902	472 316	494 938	495 243	580 449	591 565
Consumption of production	%	26.9	23.0	20.9	21.3	24.5	22.6	18.2
Lead								
Domestic consumption[3]	tonnes	99 734	89 192	107 654	106 962	100 762	126 464	124 813
Production	tonnes	126 460	171 517	175 720	187 457	194 054	183 769	162 463
Consumption of production	%	78.9	52.0	61.3	57.1	51.9	68.8	76.8
Aluminum								
Domestic consumption[4]	tonnes	359 790	293 280	332 206	322 393	380 291	399 049	329 371
Production	tonnes	1 006 632	878 056	628 049	973 524	1 048 469	860 287	1 068 197
Consumption of production	%	35.7	33.4	51.3	34.1	36.3	46.4	30.8

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[1] Production of refined metal from all sources, including metal derived from secondary materials at primary refineries. [2] Producers' domestic shipments of refined metal. [3] Consumption of primary and secondary refined metal, reported by consumers. [4] Consumption of primary refined metal, reported by consumers.

P Preliminary.

TABLE 25. AVERAGE ANNUAL PRICES[1] OF SELECTED MINERALS, 1974-80[2]

	Unit of Measure	1974	1975	1976	1977	1978	1979	1980
Aluminum, major U.S. producer	cents/lb	34.133	39.786	44.341	51.339	53.075	59.395	69.566
Antimony, New York dealer	$/lb	2.071	1.494	1.561	1.237	1.145	1.407	1.508
Asbestos, No. 4 cement fibre	Cdn $/st	306.917	389.333	492.000	551.000	642.000	687.000	769.000
Bismuth, U.S. producer	$/lb	8.410	7.715	7.500	6.010	3.378	3.011	2.637
Cadmium, U.S. producer	$/lb	4.078	3.355	2.662	2.962	2.450	2.760	2.843
Calcium, metal crowns	$/lb	1.071	1.315	1.335	1.482	1.680	1.868	2.502
Chrome, U.S. metal, 9% carbon	$/lb	1.900	2.570	2.640	2.900	3.080	3.375	4.017
Cobalt metal, shot/cathode/250 kg	$/lb	3.474	3.979	4.508	5.633	12.246	24.583	25.000
Columbium, pyrochlore	$/lb	1.557	1.560	n	n	2.550	2.550	2.550
Copper, U.S. producer refinery	cents/lb	76.649	63.535	68.824	65.808	65.510	92.334	101.416
Gold, London[3]	Cdn$/troy oz	155.670	163.781	123.107	157.089	220.407	359.289	716.087
Iridium, major producer	$/troy oz	401.670	475.000	316.667	300.000	300.000	258.333	505.833
Iron ore, taconite pellets	cents/lb	35.249	45.686	51.012	55.300	57.108	63.966	69.562
Lead, U.S. producer	cents/lb	22.533	21.529	23.102	30.703	33.653	52.642	42.455
Manganese, U.S. metal, regular	cents/lb	41.771	54.000	55.333	58.000	58.000	58.333	65.267
Magnesium, U.S. primary ingot	cents/lb	60.548	82.000	89.537	97.487	100.500	105.758	116.667
Mercury, New York	$/flask (76 lb)	281.690	158.115	121.302	135.710	153.322	281.096	389.447
Molybdenum, climax concentrate	$/lb	2.057	2.493	2.999	3.730	4.644	7.762	9.768
Nickel, major producer cathode	$/lb	1.735	2.073	2.256	2.360	2.091	2.707	3.415
Osmium, major producer	$/troy oz	200.000	200.000	200.000	170.000	150.000	150.000	150.000
Palladium, major producer	$/troy oz	133.220	92.702	50.928	59.702	70.873	113.143	213.975
Platinum, major producer	$/troy oz	180.850	164.005	161.729	162.544	237.250	351.649	439.425
Potash, K_2O, coarse major producer	cents/lb	51.167	65.667	74.667	76.000	80.583	100.417	112.667
Rhodium, major producer	$/troy oz	335.58	337.50	350.000	441.667	516.667	737.500	764.583
Ruthenium, major producer	$/troy oz	60.000	60.000	60.000	60.000	60.000	45.000	45.000
Selenium, major producer commercial	$/lb	16.333	18.000	18.000	17.000	15.000	12.250	9.654
Silver, Handy & Harman, N.Y.	$/lb	4.708	4.419	4.353	4.632	5.401	11.094	20.632
Sulphur, elemental, major producer	Cdn $/lt	13.778	22.831	17.204	15.678	17.913	25.665	58.860
Tantalum, Tanco	$/lb	n	15.000	16.000	17.750	26.479	60.014	97.604
Tellurium, major producer, slab	$/lb	8.330	9.333	10.500	17.416	20.000	20.000	19.500
Tin, New York dealer	$/lb	3.963	3.203	3.492	4.994	5.874	7.114	7.734
Titanium, ilmenite ore	$/lt	46.500	55.000	55.000	55.000	53.229	51.083	55.000
Tungsten, U.S. hydrogen red	$/lb	8.060	10.210	10.087	14.065	13.900	13.900	13.900
Uranium, U[4]	Cdn $/lb	17.70	23.60	47.20	49.90	56.70	59.00	61.20
Vanadium, pentoxide metal	$/lb	..	2.980	2.600	2.750	2.900	3.050	3.050
Zinc, U.S. high grade	cents/lb	..	39.632	30.962	34.276	37.333	37.296	37.428

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[1] Prices except for noted, are in United States currency. [2] Sources for prices include: Alberta Energy Resource Industries Monthly Statistics, Asbestos, Engineering and Mining Journal, and Metals Week. [3] Average P.M. fixings of London bullion dealers, converted to Canadian dollar. [4] From EMR publications on assessment of Canada's uranium supply and demand series EP 76-3 to EP 81-3.

.. Not available; n Nominal.

TABLE 26. CANADA, MINERAL PRODUCTS INDUSTRIES, SELLING PRICE INDEXES, 1974-80 (1971 = 100)

	1974	1975	1976	1977	1978	1979	1980P
Iron and steel products industries							
Agricultural implements industry	128.1	155.2	165.7	177.6	188.7	206.0	224.9
Hardware, tool and cutlery manufacturers	122.2	137.9	147.3	162.6	179.1	207.3	238.4
Heating equipment manufacturers	121.9	137.3	146.9	156.5	169.8	188.0	213.2
Primary metal industries	147.7	160.8	169.9	190.5	207.7	258.8	308.3
Iron and steel mills	136.6	162.0	177.2	187.9	203.9	233.7	261.7
Steel pipe and tube mills	132.0	162.9	179.1	197.8	218.0	248.1	276.9
Iron foundries	141.6	168.4	181.0	189.6	200.1	223.3	243.2
Wire and wire products manufacturers	136.6	158.3	171.0	175.4	185.8	206.4	226.9
Nonferrous metal products industries							
Aluminum rolling, casting and extruding	129.1	145.4	155.8	173.6	191.5	234.0	271.0
Copper and alloy, rolling, casting and extruding	154.8	131.6	138.4	144.5	153.0	201.8	219.6
Jewellery and silverware manufacturers	216.3	234.1	235.2	277.8	337.6	507.3	871.3
Metal rolling, casting and extruding, nes	184.2	171.8	181.0	216.3	239.8	310.4	327.3
Nonmetallic mineral products industries							
Abrasives manufacturers	114.6	140.5	167.5	194.7	223.6	255.3	290.6
Cement manufacturers	122.2	146.3	171.1	186.7	207.5	233.2	265.7
Clay products and manufacturers from imported clay	127.3	151.0	161.7	164.7	173.7	190.1	215.2
Glass and glass products manufacturers	114.5	127.1	138.6	150.4	162.1	173.4	197.0
Lime manufacturers	143.5	181.7	204.3	228.7	252.9	292.7	338.3
Concrete products manufacturers	129.7	152.0	161.5	173.7	187.7	200.1	222.5
Clay products from domestic clay	129.1	157.1	169.6	182.8	196.4	214.3	226.9
Petroleum and coal products industries	159.4	183.7	210.2	244.5	275.4	321.3	404.6
Petroleum refineries	160.1	184.5	211.5	246.7	278.7	325.8	410.6
Mixed fertilizers	167.5	204.0	176.9	180.2	191.0	229.0	280.3

Note: Industry selling price indexes reflect wholesale price trends of products or groups of products sold by the industries listed.

P Preliminary; nes Not elsewhere specified.

TABLE 27A. CANADA, PRINCIPAL STATISTICS OF THE MINING INDUSTRY[1], 1978

	Mining Activity							Total Activity[2]		
		Production and Related Workers			Costs					
	Establishments (number)	Employees (number)	Man-hours paid (000)	Wages ($000)	Fuel and Electricity ($000)	Materials and Supplies ($000)	Value of Production ($000)	Value Added ($000)	Employees (number)	Salaries and Wages ($000)	Value Added ($000)
Metals											
Gold quartz	18	4,094	8,655	65,788	11,559	48,105	267,176	207,513	4,943	81,776	207,604
Copper-gold-silver	33	10,433	22,310	195,806	68,171	679,217	1,454,800	707,412	14,604	281,031	715,921
Silver-lead-zinc	20	5,129	10,635	95,649	34,376	445,106	862,611	385,129	7,073	138,309	372,666
Nickel-copper	4	7,924	16,952	137,570	15,912	404,434	988,620	568,175	11,006	208,988	572,562
Iron	18	7,532	16,827	175,695	129,261	403,786	1,259,274	726,227	12,103	281,930	717,027
Uranium	7	3,550	6,985	61,969	18,800	118,088	614,499	477,610	4,965	90,702	501,726
Misc. metal mines	7	1,315	2,583	24,781	7,629	8,057	184,503	138,817	1,753	33,202	138,582
Total	107	39,977	84,947	757,258	285,708	2,134,793	5,631,383	3,210,883	56,447	1,115,938	3,226,088
Nonmetals											
Asbestos	10	6,039	13,812	115,186	35,952	105,995	547,438	405,491	7,752	152,379	401,552
Gypsum	11	580	1,317	8,148	2,288	10,082	38,412	26,042	683	9,808	25,930
Peat	53	1,070	2,237	11,446	1,689	9,645	44,742	33,408	1,295	14,742	33,723
Potash	9	2,815	5,807	49,118	37,161	54,294	448,572	357,117	3,708	68,958	360,170
Salt	9	929	1,969	15,212	7,392	13,384	99,212	78,436	1,381	23,401	77,868
Sand and gravel	124	1,487	3,323	22,060	8,190	24,242	117,102	84,669	1,971	32,280	85,815
Stone	125	2,255	5,319	37,664	12,139	53,978	176,645	110,528	2,876	48,386	110,165
Misc. nonmetals	29	958	2,082	15,203	9,419	11,881	66,168	44,868	1,216	19,741	44,697
Total	370	16,133	35,866	274,037	114,230	283,501	1,538,290	1,140,559	20,882	369,696	1,139,919
Fuels											
Coal	24	8,771	17,907	142,458	31,223	164,692	763,028	567,112	10,574	179,773	566,844
Oil, crude and natural gas	677	5,425	11,571	101,255	70,174	183,086	10,268,758	10,015,498	22,045	452,935	10,083,363
Total	701	14,196	29,478	243,713	101,397	347,778	11,031,787	10,582,610	32,619	632,708	10,650,207
Total mining industry	1,178	70,306	150,291	1,275,008	501,335	2,766,072	18,201,460	14,934,052	109,948	2,118,342	15,016,214

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[1] Cement manufacturing, lime manufacturers, clay and clay products (domestic clays) are included in the mineral manufacturing industry. Industry coverage is the same as in Tables 29, 31 and 33. [2] Total activity includes sales and head offices.

TABLE 27B. CANADA, PRINCIPAL STATISTICS OF THE MINING INDUSTRY[1], 1979

	Mining Activity								Total Activity[2]		
		Production and Related Workers			Costs						
	Establishments (number)	Employees (number)	Man-hours paid (000)	Wages ($000)	Fuel and Electricity ($000)	Materials and Supplies ($000)	Value of Production ($000)	Value Added ($000)	Employees (number)	Salaries and Wages ($000)	Value Added ($000)
Metals											
Gold quartz	21	4,155	8,521	75,979	13,952	54,883	391,357	322,522	5,013	93,926	322,797
Copper-gold-silver	33	10,976	23,172	231,527	73,926	748,409	2,254,887	1,432,552	14,945	322,094	1,434,545
Silver-lead-zinc	20	5,087	10,514	103,783	37,216	495,696	1,215,109	682,197	7,081	149,876	671,894
Nickel-copper	3	7,159	13,508	137,967	17,024	415,781	1,466,921	1,034,116	10,171	215,552	1,035,140
Iron	17	8,911	18,957	221,216	175,432	612,083	1,851,539	1,064,024	14,563	372,738	1,022,199
Uranium	7	4,320	8,482	87,902	22,874	118,740	656,955	515,341	5,858	122,524	525,353
Misc. metal mines	7	933	1,925	21,009	7,309	30,244	217,647	180,094	1,329	31,312	179,658
Total	108	41,541	85,079	879,383	347,733	2,475,836	8,054,415	5,230,846	58,960	1,308,022	5,191,586
Nonmetals											
Asbestos	9	6,391	15,386	145,417	43,197	128,023	626,785	455,565	8,067	184,575	456,780
Gypsum	11	633	1,361	8,818	2,722	10,953	41,279	27,605	738	10,699	27,497
Peat	54	1,147	2,416	13,346	1,997	11,115	49,430	36,318	1,372	17,011	38,832
Potash	10	2,886	5,944	56,047	45,592	76,299	732,401	610,510	3,905	80,824	613,470
Salt	9	936	2,163	18,543	8,352	17,597	113,121	87,173	1,424	28,314	86,365
Sand and gravel	113	1,369	3,123	22,782	8,765	24,026	120,686	87,895	1,832	33,602	91,450
Stone	118	2,265	5,037	39,399	13,521	52,649	188,099	121,930	2,860	51,091	121,655
Misc. nonmetals	29	1,006	2,129	16,951	11,335	15,711	80,958	53,911	1,264	21,962	53,747
Total	353	16,633	37,559	321,303	135,482	336,371	1,952,759	1,480,907	21,462	428,079	1,489,796
Fuels											
Coal	25	8,642	17,695	176,522	37,286	172,034	868,120	658,800	10,269	213,878	658,584
Oil, crude and natural gas	664	5,764	12,227	116,565	79,948	268,750	12,751,436	12,402 738	24,554	542,736	12,559,657
Total	689	14,406	29,922	293,087	117,234	440,784	13,619,556	13,061,538	34,823	756,614	13,218,241
Total mining industry	1,150	72,580	152,560	1,493,773	600,448	3,252,991	23,626,730	19,773,291	115,245	2,492,715	19,899,623

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[1] Cement manufacturing, lime manufacturers, clay and clay products (domestic clays) are included in the mineral manufacturing industries. Industry coverage is the same as in Tables 29, 31 and 33. [2] Total activity includes sales and head offices.

TABLE 28A. CANADA, PRINCIPAL STATISTICS OF THE MINERAL MANUFACTURING INDUSTRIES[1], 1978

		Mineral Manufacturing Activity							Total Activity[2]		
		Production and related workers			Costs						
	Establishments (number)	Employees (number)	Man-hours paid (000)	Wages ($000)	Fuel and Electricity ($000)	Materials and Supplies ($000)	Value of Production ($000)	Value Added ($000)	Employees (number)	Salaries and Wages ($000)	Value Added ($000)
Primary metal industries											
Iron and steel mills	50	44,791	89,851	777,594	297,045	2,556,024	4,827,476	1,928,828	56,669	1,041,367	1,924,922
Steel pipe and tube mills	31	5,301	11,809	89,247	13,559	434,589	657,807	221,388	6,289	109,519	225,058
Iron foundries	110	8,812	17,778	128,781	18,334	200,210	487,148	226,848	10,472	161,088	273,825
Smelting and refining	31	22,138	45,445	379,118	202,031	822,937	2,371,301	1,346,333	32,652	602,191	1,387,242
Aluminum rolling, casting and extruding	61	5,453	10,757	72,058	14,557	630,252	791,839	154,153	7,060	102,428	154,311
Copper and alloy rolling casting and extruding	37	3,017	6,149	46,386	8,058	353,105	452,344	95,485	3,586	57,067	93,093
Metal rolling, casting and extruding, nes	82	4,286	8,809	51,228	9,404	265,522	399,485	129,161	5,268	67,296	136,233
Total	402	93,798	190,598	1,544,412	562,988	5,262,639	9,987,400	4,102,196	121,996	2,140,956	4,194,684
Nonmetallic mineral products industries											
Cement manufacturers	29	2,873	6,173	58,160	114,631	90,170	526,831	320,194	4,520	93,867	319,905
Lime manufacturers	15	601	1,260	9,433	21,796	8,517	74,673	44,517	784	13,078	44,633
Concrete products manufacturers	499	8,158	17,368	120,157	17,344	211,507	530,123	302,121	10,486	162,012	309,266
Ready-mix concrete manufacturers	440	7,471	16,077	126,720	22,364	434,437	761,840	305,617	9,520	161,885	317,347
Clay products manufacturers (domestic)	116	2,133	4,644	28,541	15,509	24,464	110,708	72,367	2,670	38,437	73,584
Clay products manufacturers (imported)	36	1,326	2,757	17,057	2,963	19,958	64,782	42,304	1,696	22,365	43,111
Refractories manufacturers	19	902	1,893	13,611	7,889	54,047	98,666	41,674	1,499	23,959	45,276
Stone products manufacturers	134	918	1,908	10,353	836	14,545	37,821	22,509	1,088	12,896	22,392
Glass manufacturers	13	6,331	13,393	97,360	35,715	103,001	408,696	270,004	8,303	134,980	266,826
Glass products manufacturers	89	2,765	5,825	40,106	5,016	101,963	228,642	120,956	3,292	51,897	122,866
Abrasive manufacturers	23	2,030	4,310	29,180	20,735	82,059	171,304	68,799	2,678	40,800	70,632
Other nonmetallic mineral products industries	103	5,789	12,205	87,474	36,527	232,553	585,627	318,495	9,200	146,142	340,963
Total	1,516	41,297	87,813	638,152	301,325	1,377,221	3,599,713	1,929,557	55,736	902,318	1,976,801
Petroleum and coal products industries											
Petroleum refining industry	41	7,918	17,243	169,875	113,354	8,901,457	10,220,111	1,174,772	18,958	427,950	1,180,439
Manufacture of lubricating oils & greases	19	414	861	6,252	1,471	99,405	133,938	34,979	712	11,704	36,887
Other petroleum & coal products industries	44	490	1,039	7,091	2,368	59,892	95,377	30,794	683	11,408	33,086
Total	104	8,822	19,143	183,218	117,193	9,060,754	10,449,426	1,240,545	20,353	451,062	1,250,412
Total, mineral manufacturing industries	2,022	143,917	297,554	2,365,782	981,506	15,700,614	24,036,539	7,272,298	198,085	3,494,336	7,421,897

[1] Industry coverage is the same as in Tables 28, 30 and 32. [2] Includes sales and head offices.
nes - Not elsewhere specified.

TABLE 28B. CANADA, PRINCIPAL STATISTICS OF THE MINERAL MANUFACTURING INDUSTRIES[1], 1979

		Mineral Manufacturing Activity							Total Activity[2]		
		Production and related workers			Costs						
	Establishments (number)	Employees (number)	Man-hours paid (000)	Wages ($000)	Fuel and Electricity ($000)	Materials and Supplies ($000)	Value of Production ($000)	Value Added ($000)	Employees (number)	Salaries and Wages ($000)	Value Added ($000)
Primary metal industries											
Iron and steel mills	53	46,977	98,901	897,435	332,856	3,225,262	5,859,261	2,436,651	59,167	1,188,608	2,424,283
Steel pipe and tube mills	36	5,221	11,270	97,424	15,522	567,510	838,072	278,259	6,480	124,902	280,384
Iron foundries	115	8,835	18,121	136,360	23,462	236,719	538,345	291,576	10,520	171,985	298,155
Smelting and refining	32	20,675	43,467	383,241	207,354	871,940	2,413,124	1,333,830	32,869	664,974	1,401,011
Aluminum rolling, casting and extruding	67	5,941	12,383	89,050	17,981	758,368	1,007,205	248,172	7,698	126,043	249,038
Copper and alloy rolling, casting and extruding	41	3,179	6,496	53,499	9,166	475,903	607,930	134,410	3,728	64,373	131,508
Metal rolling, casting and extruding, nes	97	5,114	10,475	68,894	11,751	409,199	592,513	191,724	6,292	91,298	198,900
Total	441	95,942	201,113	1,725,904	618,092	6,544,901	11,856,450	4,914,622	126,754	2,432,183	4,983,279
Nonmetallic mineral products industries											
Cement manufacturers	28	2,909	6,515	68,501	143,437	133,233	642,967	381,817	4,828	113,056	388,762
Lime manufacturers	15	707	1,546	13,205	31,817	12,315	93,170	48,971	925	17,654	49,271
Concrete products manufacturers	505	7,502	16,015	123,475	17,452	230,120	566,030	322,573	9,766	166,036	328,704
Ready-mix concrete manufacturers	472	7,308	15,852	136,749	25,267	508,785	858,507	326,292	9,332	173,961	341,558
Clay products manufacturers (domestic)	115	2,557	5,417	35,768	17,865	30,872	132,118	85,584	3,167	48,350	87,520
Clay products manufacturers (imported)	38	1,412	2,971	19,834	3,566	24,467	71,398	44,297	1,780	25,776	44,920
Refractories manufacturers	20	1,002	2,135	15,831	9,895	76,212	139,732	57,561	1,606	27,632	66,647
Stone products manufacturers	135	1,036	2,145	12,968	965	16,982	45,472	28,212	1,205	15,698	28,167
Glass manufacturers	13	6,345	13,038	104,444	40,036	123,868	450,795	298,205	8,421	145,897	294,936
Glass products manufacturers	100	2,862	6,254	45,608	5,582	114,978	251,309	132,399	3,414	58,215	141,041
Abrasive manufacturers	24	2,036	4,366	32,691	23,172	95,286	192,940	77,568	2,660	45,853	79,421
Other nonmetallic mineral products industries	101	6,137	13,012	101,548	42,637	265,728	647,014	344,398	9,644	169,705	375,230
Total	1,566	41,813	89,266	710,622	361,691	1,632,846	4,091,452	2,147,877	56,748	1,007,833	2,226,177
Petroleum and coal products industries											
Petroleum refining industry	41	7,373	16,708	172,183	134,270	10,775,892	12,143,764	1,397,086	18,037	450,330	1,390,928
Manufacture of lubricating oils & greases	20	438	908	6,549	1,551	104,517	138,850	34,743	695	11,585	38,338
Other petroleum & coal products industries	47	363	775	6,558	2,542	58,213	88,174	27,700	461	8,523	30,518
Total	108	8,174	18,391	185,290	138,363	10,938,622	12,370,788	1,459,529	19,193	470,438	1,459,784
Total, mineral manufacturing industries	2,115	145,929	308,770	2,621,816	1,118,146	19,116,369	28,318,690	8,522,028	202,695	3,910,454	8,669,240

[1] Industry coverage is the same as in Tables 28, 30 and 32. [2] Includes sales and head offices.
nes - Not elsewhere specified.

TABLE 29. CANADA, PRINCIPAL STATISTICS OF THE MINING INDUSTRY[1], 1973-79

	Mineral Manufacturing Activity								Total Activity[2]		
		Production and Related Workers			Costs						
	Establishments (number)	Employees (number)	Man-hours paid (000)	Wages ($000)	Fuel and Electricity ($000)	Materials and Supplies ($000)	Value of Production ($000)	Value Added ($000)	Employees (number)	Salaries and Wages ($000)	Value Added ($000)
1973	1,626	75,165	156,960	751,878	215,096	1,551,560	8,030,314	6,263,659	111,443	1,214,871	6,288,935
1974	1,438	79,928	165,999	894,538	285,767	2,004,476	11,187,764	8,897,522	118,730	1,450,330	8,929,981
1975	1,345	77,091	159,431	1,030,009	319,496	2,214,191	12,240,016	9,706,329	115,715	1,655,278	9,750,032
1976	1,244	78,989	163,426	1,185,184	401,899	2,438,672	14,178,010	11,337,439	117,694	1,902,682	11,360,511
1977	1,232	79,902r	167,884	1,342,508	473,202	2,715,468	16,400,460	13,211,792	119,061r	2,137,523	13,246,689
1978	1,179	70,306	150,291	1,275,008	501,335	2,766,072	18,201,459	14,934,052	109,948	2,118,342	15,016,214
1979	1,150	72,580	152,560	1,493,773	600,448	3,252,991	23,546,742	19,693,303	115,245	2,492,715	19,899,635

[1] Cement manufacturing, lime manufacturers, clay and clay products (domestic clays) are included in the mineral manufacturing industries. Industry coverage is the same as in Tables 27, 31 and 33. [2] Includes sales and head offices.

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TABLE 30. CANADA, PRINCIPAL STATISTICS OF THE MINERAL MANUFACTURING INDUSTRIES[1], 1973-79

	Mineral Manufacturing Activity								Total Activity[2]		
		Production and Related Workers			Costs						
	Establishments	Employees	Man-hours paid	Wages	Fuel and electricity	Materials and supplies	Value of production	Value added	Employees	Salaries and wages	Value added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
1973	1,749	138,177	295,213	1,347,918	349,521	5,735,529	9,914,174	3,934,216	188,498	1,970,456	4,039,415
1974	1,708	145,209	309,481	1,582,014	463,395	8,809,583	14,003,237	5,110,117	197,220	2,315,107	5,236,626
1975	1,680	140,195	290,264	1,712,892	541,650	9,724,522	15,205,070	5,183,708	193,526	2,580,313	5,316,534
1976	1,662	137,310	284,392	1,898,753	655,828	10,798,653	16,793,147	5,548,868	188,751	2,820,873	5,687,750
1977	1,616	138,700	288,409	2,110,400	798,486	12,743,217	19,725,082	6,489,111	189,576	3,114,744	6,594,794
1978	2,022	143,917	297,554	2,365,782	981,506	15,700,614	24,036,539	7,272,298	198,085	3,494,336	7,421,897
1979	2,115	145,929	308,770	2,614,816	1,118,146	19,116,369	28,318,690	8,522,128	202,695	3,910,454	8,669,240

[1] Industry coverage is the same as in Tables 28, 32 and 34. [2] Includes sales and head offices.

TABLE 31A. CANADA, CONSUMPTION OF FUEL AND ELECTRICITY IN THE MINING INDUSTRY[1], 1978

	Unit	Metals	Nonmetals	Fuels	Total
Coal and coke	000 t	162	13	-	175
	$000	4,419	171	-	4,590
Gasoline	000 litres	24 849	27 872	7 692	60 408
	$000	4,624	5,140	1,251	11,016
Fuel oil, kerosene, diesel oil	000 litres	1 089 889	341 267	87 769	1 518 925
	$000	112,778	42,065	11,933	166,775
Liquefied petroleum gas	000 litres	96 750	6 583	8 128	111 466
	$000	9,623	856	653	11,131
Natural gas	000 m^3	331 024	738 277	111 030	1 180 331
	$000	22,099	30,857	5,936	58,892
Other fuels[2]	$000	66	-	-	66
Total value of fuels	$000	153,608	79,090	19,773	252,470
Electricity purchased	million kwh	10 739	2 082	2 699	15 520
	$000	132,100	35,141	81,624	248,865
Total value of fuels and electricity purchased, all reporting companies	$000	285,708	114,231	101,398	501,335

[1] Cement and lime manufacturing and manufacturers of clay products (domestic clays) are included under mineral manufacturing, Tables 32 and 34. Industry coverage is the same as in Tables 27, 29, and 33. [2] Includes wood, manufactured gas, steam purchased and other miscellaneous fuels.

- Nil.

Note: Totals may not add due to rounding.

TABLE 31B. CANADA, CONSUMPTION OF FUEL AND ELECTRICITY IN THE MINING INDUSTRY[1], 1979

	Unit	Metals	Nonmetals	Fuels	Total
Coal and coke	000 t	165	12	-	177
	$000	4,749	204	-	4,953
Gasoline	000 litres	25 132	26 386	9 068	60 586
	$000	5,241	5,161	1,498	11,900
Fuel oil, kerosene, diesel oil	000 litres	1 361 003	370 698	107 378	1 839 079
	$000	152,295	48,870	14,720	215,885
Liquefied petroleum gas	000 litres	94 694	7 041	7 149	108 884
	$000	9,405	992	738	11,135
Natural gas	000 m^3	295 191	771 552	177 000	1 243 743
	$000	22,125	37,270	7,031	66,426
Other fuels[2]	$000	13	-	-	13
Total value of fuels	$000	193,828	92,499	23,988	310,315
Electricity purchased	million kwh	11 459	2 244	3 238	16 941
	$000	153,905	42,982	98,783	295,670
Total value of fuels and electricity purchased, all reporting companies	$000	347,733	135,481	122,771	605,985

[1] Cement and lime manufacturing and manufacturers of clay products (domestic clays) are included under mineral manufacturing, Tables 32 and 34. Industry coverage is the same as in Tables 27, 29, and 33. [2] Includes wood, manufactured gas, steam purchased and other miscellaneous fuels.

- Nil.

Note: Totals may not add due to rounding.

TABLE 32A. CANADA, CONSUMPTION OF FUEL AND ELECTRICITY IN THE MINERAL MANUFACTURING INDUSTRIES[1], 1978

	Unit	Primary Metal Industries	Nonmetallic Mineral Products Industries	Petroleum and Coal Products Industries	Total
Coal and coke	000 t	356	565	2	923
	$000	30,951	20,602	101	51,654
Gasoline	000 litres	18 612	49 684	2 341	70 637
	$000	3,102	8,777	439	12,318
Fuel oil, kerosene, diesel oil	000 litres	1 473 265	855 974	51 544	2 380 783
	$000	121,951	78,235	3,891	204,077
Liquefied petroleum gas	000 litres	42 297	20 912	38 378	101 587
	$000	4,550	2,414	2,004	8,968
Natural gas	000 m^3	2 555 907	1 751 935	928 906	5 236 748
	$000	167,969	109,676	51,372	329,017
Other fuels	$000	8,159	2,154	4,085	14,398
Total value of fuels	$000	336,684	221,855	61,891	620,430
Electricity purchased	million kWh	17 257	4 782	3 505	25 544
	$000	226,313	79,606	55,303	361,222
Total value of fuels and electricity purchased, all reporting companies	$000	562,997	301,461	117,194	981,652

[1] Industry coverage is the same as in Tables 28, 30 and 34.
- Nil.

TABLE 32B. CANADA, CONSUMPTION OF FUEL AND ELECTRICITY IN THE MINERAL MANUFACTURING INDUSTRIES[1], 1979

	Unit	Primary Metal Industries	Nonmetallic Mineral Products Industries	Petroleum and Coal Products Industries	Total
Coal and coke	000 t	214	702	-	916
	$000	19,280	27,495	-	46,775
Gasoline	000 litres	16 207	57 590	2 555	76 352
	$000	2,983	11,265	531	14,779
Fuel oil, kerosene, diesel oil	000 litres	1 330 627	1 020 029	23 494	2 374 150
	$000	130,477	107,524	2,204	240,205
Liquefied petroleum gas	000 litres	35 491	22 412	92 358	150 261
	$000	3,929	2,842	5,975	12,746
Natural gas	000 m^3	2 778 760	1 844 523	1 034 410	5 657 693
	$000	198,676	129,175	61,160	389,011
Other fuels	$000	2,429	2,547	5,100	10,076
Total value of fuels	$000	357,775	280,846	74,968	713,589
Electricity purchased	million kWh	18 451	5 163	3 555	27 169
	$000	260,317	98,296	63,395	422,008
Total value of fuels and electricity purchased, all reporting companies	$000	618,092	379,142	138,363	1,135,597

[1] Industry coverage is the same as in Tables 28, 30 and 34.
- Nil.

TABLE 33. CANADA, COST OF FUEL AND ELECTRICITY USED IN THE MINING INDUSTRY[1], 1973-79

	Unit	1973	1974	1975	1976	1977	1978	1979
Metals								
Fuel	$000	54,430	90,596	107,808	128,637	148,578	153,608	193,828
Electricity purchased	million kwh	10 032	10 282	10 259	11 326	11 713	10 739	11 459
	$000	68,089	77,669	85,063	107,318	135,014	132,100	153,905
Total cost of fuel and electricity	$000	122,519	168,265	192,871	235,955	283,591	285,708	347,733
Nonmetals[2]								
Fuel	$000	29,101	42,209	46,561	62,453	72,946	79,090	92,499
Electricity purchased	million kwh	1 782	2 015	1 763	1 959	2 457	2 082	2 244
	$000	16,593	20,065	20,049	23,401	29,510	35,141	42,982
Total cost of fuel and electricity	$000	45,694	62,274	66,610	85,854	102,456	114,231	135,481
Fuels								
Fuels	$000	4,600	5,755	11,352	12,015	15,117	19,774	23,988
Electricity purchased	million kwh	2 792	2 972	2 539	2 770	2 791	2 699	3 238
	$000	42,283	49,473	48,663	68,075	72,035	81,624	98,783
Total cost of fuel and electricity	$000	46,883	55,228	60,015	80,090	87,152	101,398	122,771
Total mining industry								
Fuel	$000	88,131	138,560	165,721	203,105	236,642	252,470	310,315
Electricity purchased	million kwh	14 606	15 267	14 560	16 055	16 961	15 520	16 941
	$000	126,965	147,207	153,775	198,794	236,559	248,865	295,670
Total cost of fuel and electricity	$000	215,096	285,767	319,496	401,899	473,201	501,335	605,985

[1] Cement and lime manufacturing and manufacture of clay products (domestic clays) are included in mineral manufacturing, Tables 32 and 34. Industry coverage is the same as in Tables 27, 29 and 31. [2] Includes structural materials.

.. Not available; - Nil.

TABLE 34. CANADA, COST OF FUEL AND ELECTRICITY USED IN THE MINERAL MANUFACTURING INDUSTRIES[1], 1973–79

	Unit	1973	1974	1975	1976	1977	1978	1979
Primary metals								
Fuel	$ 000	103,321	153,468	187,846	224,928	279,172	336,684	357,775
Electricity purchased	million kwh	16 584	17 727	16 544	16 497	15 352	17 257	18 451
	$ 000	108,575	122,567	129,750	151,011	183,574	226,313	260,317
Total cost of fuel and electricity	$ 000	211,896	276,035	317,596	375,939	462,746	562,997	618,092
Nonmetallic mineral products								
Fuel	$ 000	75,144	112,531	133,016	162,312	181,952	221,855	280,946
Electricity purchased	million kwh	4 080	4 106	3 723	4 137	4 190	4 782	5 163
	$ 000	34,624	38,671	41,258	52,113	65,553	79,606	98,296
Total cost of fuel and electricity	$ 000	109,768	151,202	174,274	214,425	247,507	301,461	379,142
Petroleum and coal products								
Fuel	$ 000	7,796	13,275	21,758	30,474	42,184	61,891	74,968
Electricity purchased	million kwh	2 683	2 715	2 904	3 010	3 205	3 505	3 555
	$ 000	20,061	22,885	28,028	34,988	46,050	55,303	63,395
Total cost of fuel and electricity	$ 000	27,857	36,160	49,786	65,462	88,233	117,194	138,363
Total mineral manufacturing industries								
Fuel	$ 000	186,261	279,274	342,620	417,714	503,308	620,430	713,589
Electricity purchased	million kWh	23 347	24 548	23 171	23 644	22 747	25 544	27 169
	$ 000	163,260	184,123	199,036	238,112	295,177	361,222	422,008
Total cost of fuel and electricity	$ 000	349,521	463,397	541,656	655,826	798,486	981,652	1,135,597

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[1] Industry coverage is the same as in Tables 28, 30 and 32.

TABLE 35. CANADA, EMPLOYMENT, SALARIES AND WAGES IN THE MINING INDUSTRY[1], 1973-79

	Unit	1973	1974	1975	1976	1977	1978	1979
Metals								
Production and related workers	Number	47,984	50,886	50,319	49,834	49,414	39,977	41,541
Salaries and wages	$000	494,631	580,185	685,562	759,499	849,345	757,258	879,383
Annual average salary and wage	$	10,308	11,402	13,624	15,241	17,188	18,942	21,169
Administrative and office workers	Number	18,150	19,152	18,842	18,435	17,831	16,470	17,419
Salaries and wages	$000	238,454	282,348	320,873	352,847	377,714	358,680	428,639
Annual average salary and wage	$	13,138	14,732	17,030	19,140	21,183	21,778	24,608
Total metals								
Employees	Number	66,134	70,038	69,161	68,269	67,245	56,447	58,960
Salaries and wages	$000	733,085	862,533	1,006,435	1,112,346	1,227,059	1,115,938	1,308,022
Annual average salary and wage	$	11,085	12,315	14,552	16,294	18,248	19,770	22,185
Nonmetals								
Production and related workers	Number	16,332	17,767	15,397	16,447	16,812	16,133	16,633
Salaries and wages	$000	147,027	180,962	188,956	237,982	266,294	274,037	321,303
Annual average salary and wage	$	9,002	10,185	12,272	14,470	15,840	16,986	19,317
Administrative and office workers	Number	4,335	4,628	4,688	4,887	4,986	4,749	4,829
Salaries and wages	$000	47,092	57,243	69,208	82,861	89,757	95,659	106,776
Annual average salary and wage	$	10,863	12,369	14,763	16,955	18,002	20,143	22,114
Total nonmetals								
Employees	Number	20,667	22,395	20,085	21,334	21,798	20,882	21,462
Salaries and wages	$000	194,119	238,205	258,164	320,843	356,051	369,696	428,079
Annual average salary and wage	$	9,393	10,637	12,854	15,039	16,334	17,704	19,946
Fuels								
Production and related workers	Number	10,849	11,275	11,375	12,708	13,679	14,196	14,406
Salaries and wages	$000	110,220	133,392	155,491	187,704	226,869	243,713	293,087
Annual average salary and wage	$	10,160	11,831	13,670	14,771	16,585	17,168	20,345
Administrative and office workers	Number	13,793	15,022	15,094	15,383	16,342	18,423	20,417
Salaries and wages	$000	177,447	216,200	235,188	281,789	327,544	388,995	463,527
Annual average salary and wage	$	12,865	14,392	15,582	18,318	20,043	21,115	22,703
Total fuels								
Employees	Number	24,642	26,297	26,469	28,091	30,021	32,619	34,823
Salaries and wages	$000	287,667	349,592	390,679	469,493	554,413	632,708	756,614
Average annual salary and wage	$	11,674	13,294	14,760	16,713	18,468	19,397	21,727
Total mining								
Production and related workers	Number	75,165	79,928	77,091	78,989	79,905	70,306	72,580
Salaries and wages	$000	751,878	894,538	1,030,009	1,185,184	1,342,508	1,275,008	1,493,773
Average annual salary and wage	$	10,003	11,192	13,361	15,004	16,801	18,135	20,581
Administrative and office workers	Number	36,278	38,802	38,624	38,705	39,159	39,642	42,665
Salaries and wages	$000	462,993	555,792	625,269	717,498	795,015	843,335	998,942
Annual average salary and wage	$	12,762	14,324	16,189	18,538	20,302	21,274	23,414
Total mining								
Employees	Number	111,443	118,730	115,715	117,694	119,064	109,948	115,245
Salaries and wages	$000	1,214,871	1,450,330	1,655,278	1,902,682	2,137,523	2,118,343	2,492,715
Annual average salary and wage	$	10,901	12,215	14,305	16,166	17,954	19,267	21,630

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[1] Does not include cement and lime manufacturing and clay products (domestic clays) manufacturing. These industries are included in Table 36 under "Nonmetallic mineral products industries". See Table 27 for detail of industries.

TABLE 36. CANADA, EMPLOYMENT, SALARIES AND WAGES IN THE MINERAL MANUFACTURING INDUSTRIES[1], 1973-79

	Unit	1973	1974	1975	1976	1977	1978	1979
Primary metal industries								
Production and related workers	Number	89,853	94,538	90,169	88,939	91,683	93,798	95,942
Salaries and wages	$000	897,353	1,052,519	1,119,159	1,241,893	1,399,390	1,544,412	1,725,904
Annual average salary and wage	$	9,987	11,133	12,412	13,963	15,263	16,465	17,989
Administrative and office workers	Number	26,609	27,681	30,161	28,102	27,536	28,198	30,812
Salaries and wages	$000	340,547	403,151	493,764	511,236	545,957	597,544	713,279
Annual average salary and wage	$	12,798	14,564	16,371	18,192	19,827	21,191	23,149
Total primary metal industries								
Employees	Number	116,462	122,219	120,330	117,041	119,219	121,996	126,754
Salaries and wages	$000	1,237,900	1,455,671	1,612,923	1,753,128	1,945,347	2,140,956	2,432,183
Annual average salary and wage	$	10,629	11,910	13,404	14,979	16,317	17,549	19,188
Nonmetallic mineral products industries								
Production and related workers	Number	41,502	42,884	42,149	41,272	39,321	41,297	41,813
Salaries and wages	$000	366,028	424,096	471,466	529,264	564,444	638,152	710,622
Annual average salary and wage	$	8,820	9,889	11,186	12,824	14,355	15,452	16,995
Administrative and office workers	Number	14,447	14,682	13,783	13,749	13,187	14,439	14,935
Salaries and wages	$000	156,085	180,802	197,884	218,164	229,855	264,166	297,211
Annual average salary and wage	$	10,804	12,314	14,357	15,868	17,430	18,295	19,900
Total nonmetallic mineral products								
Employees	Number	55,949	57,566	55,932	55,021	52,508	55,736	56,748
Salaries and wages	$000	522,113	604,898	669,350	747,428	794,299	902,318	1,007,833
Annual average salary and wage	$	9,332	10,507	11,967	13,584	15,127	16,189	17,760
Petroleum and coal products industries								
Production and related workers	Number	6,822	7,787	7,877	7,099	7,696	8,822	8,174
Salaries and wages	$000	84,537	105,398	122,268	127,594	146,566	183,218	185,290
Annual average salary and wage	$	12,392	13,535	15,522	17,974	19,044	20,768	22,668
Administrative and office workers	Number	9,265	9,648	9,387	9,590	10,153	11,531	11,019
Salaries and wages	$000	125,906	149,140	175,772	192,722	228,532	267,844	285,148
Annual average salary and wage	$	13,589	15,458	18,725	20,096	22,509	23,228	25,887
Total petroleum and coal products								
Employees	Number	16,087	17,435	17,264	16,689	17,849	20,353	19,193
Salaries and wages	$000	210,443	254,539	298,040	320,316	375,098	451,062	470,438
Annual average salary and wage	$	13,082	14,599	17,264	19,193	21,015	22,162	24,511
Total mineral manufacturing								
Production and related workers	Number	138,177	145,209	140,195	137,310	138,700	143,917	145,929
Salaries and wages	$000	1,347,918	1,582,014	1,712,892	1,898,751	2,110,400	2,365,782	2,621,816
Annual average salary and wage	$	9,755	10,895	12,218	13,828	15,216	16,439	17,966
Administrative and office workers	Number	50,321	52,011	53,331	51,441	50,876	54,168	56,766
Salaries and wages	$000	622,538	733,093	867,421	922,122	1,004,344	1,129,554	1,295,638
Annual average salary and wage	$	12,371	14,095	16,269	17,926	19,741	20,853	22,824
Total mineral manufacturing industries								
Employees	Number	188,498	197,220	193,526	188,751	189,576	198,085	202,695
Salaries and wages	$000	1,970,456	2,315,107	2,580,313	2,820,872	3,114,744	3,494,336	3,910,454
Annual average salary and wage	$	10,454	11,739	13,333	14,945	16,430	17,641	19,292

Note: See footnote, Table 35. See Table 28 for detail of industries covered.

TABLE 37. CANADA, NUMBER OF WAGE EARNERS EMPLOYED IN THE MINING INDUSTRY, (SURFACE, UNDERGROUND AND MILL), 1973-79

	1973	1974	1975	1976	1977	1978	1979
Metals							
Surface	15,060	16,229	16,230	16,143	16,115	12,901	12,664
Underground	20,336	21,045	20,555	20,043	19,482	15,682	15,906
Mill	12,588	13,612	13,534	13,648	13,817	11,394	12,971
Total	47,984	50,886	50,319	49,834	49,414	39,977	41,541
Nonmetals							
Surface	7,080	7,743	7,180	7,264	7,166	6,660	6,877
Underground	1,881	2,210	1,870	2,180	2,245	2,275	2,370
Mill	7,383	7,814	6,347	7,003	7,401	7,198	7,386
Total	16,344	17,767	15,397	16,447	16,812	16,133	16,633
Fuels							
Surface	7,820	8,443	8,789	9,705	10,510	11,045	11,535
Underground	3,029	2,832	2,586	3,003	3;169	3,151	2,871
Total	10,849	11,275	11,375	12,708	13,679	14,196	14,406
Total mining industry							
Surface	29,960	32,415	32,200	33,112	33,791	30,606	31,076
Underground	22,246	26,087	25,010	25,226	24,896	21,108	21,147
Mill	19,971	21,426	19,881	20,651	21,218	18,592	20,357
Total	75,177	79,928	77,091	78,989	79,905	70,306	72,580

TABLE 38. CANADA, MINE AND MILL WORKERS BY SEX, 1979

	Mine Workers				Mill Workers		Total	
	Underground		Surface					
	Male	Female	Male	Female	Male	Female	Male	Female
Metallic Minerals								
Gold-quartz	2,537	-	829	23	748	18	4,114	41
Copper-gold-silver	3,628	10	3,561	132	3,486	159	10,675	301
Silver-lead-zinc	2,082	2	1,280	62	1,596	65	4,958	129
Nickel-copper	4,639	3	1,977	25	510	5	7,126	33
Iron Ore	296	-	3,121	72	5,231	191	8,648	263
Uranium	2,487	3	1,137	19	645	29	4,269	51
Miscellaneous metal mines	219	-	412	14	278	10	909	24
Total	15,888	18	12,317	347	12,494	477	40,699	842
Industrial minerals								
Asbestos	528	-	1,990	16	3,788	69	6,306	85
Feldspar, quartz and nepheline syenite	-	-	213	1	253	2	466	3
Gypsum	116	-	480	3	34	-	630	3
Peat	-	-	577	21	535	14	1,112	35
Potash	1,352	9	45	-	1,448	32	2,845	41
Salt	320	-	191	-	405	20	916	20
Sand and gravel	-	-	1,241	9	118	1	1,359	10
Stone	6	-	2,001	4	249	5	2,256	9
Talc and soapstone	12	-	37	-	39	-	88	-
Miscellaneous nonmetals	27	-	44	4	371	3	442	7
Total	2,361	9	6,819	58	7,240	146	16,420	213
Mining Total	18,249	27	19,136	405	19,734	623	57,119	1,055

TABLE 39. CANADA, LABOUR COSTS IN RELATION TO TONNES MINED, METAL MINES, 1977-79

Type of metal mine	Number of wage earners	Total wages	Average annual wage	Tonnage of ore mined	Average annual tonnes mined per wage earner	Wage cost per tonne mined
		($000)	($)	(kilotonnes)		($)
1977						
Gold-quartz	3,837[r]	58,542	15,257[r]	5 768	1 503[r]	10.15
Copper-gold-silver	11,362	203,753	17,933	108 966	9 590	1.87
Nickel-copper	14,295	214,763	15,024	20 395	1 427	10.53
Silver-lead-zinc	5,500	97,192	17,671	16 730[r]	3 042[r]	5.81[r]
Iron ore	10,070	202,926	20,152	127 057	12 617	1.60
Uranium	3,041	49,561	16,298	5 014	1 649	9.88
Miscellaneous metals	1,306	22,609	17,312	15 599	11 561	1.50
Total	49,411[r]	849,346[r]	17,189[r]	299 529	6 062	2.84
1978						
Gold-quartz	4,094	65,788	16,069	5 914	1 445	11.12
Copper-gold-silver	10,433	195,806	18,768	98 307	9 423	1.99
Nickel-copper	7,924	137,570	17,361	11 306	1 427	12.17
Silver-lead-zinc	5,129	95,649	18,649	15 859	3 092	6.03
Iron ore	7,532	175,695	23,326	96 323	12 789	1.82
Uranium	3,550	61,969	17,456	6 126	1 726	10.11
Miscellaneous metals	1,315	24,781	18,845	14 221	10 814	1.74
Total	39,977	757,258	18,942	248 056	6 205	3.05
1979						
Gold-quartz	4,155	75,979	18,286	5 478	1 318	13.87
Copper-gold-silver	10,976	231,527	21,040	99 254	9 043	2.33
Nickel-copper	7,159	137,967	19,272	10 183	1 422	13.55
Silver-lead-zinc	5,087	103,783	20,402	15 078	2 964	6.88
Iron ore	8,911	221,216	24,825	130 799	14 678	1.69
Uranium	4,320	87,902	20,348	6 141	1 422	14.31
Miscellaneous metals	933	21,009	22,518	7 822	8 384	2.50
Total	41,541	879,383	21,169	274 755	6 614	3.20

[r] Revised.

TABLE 40. CANADA, MAN-HOURS PAID, PRODUCTION AND RELATED WORKERS, TONNES OF ORE MINED AND ROCK QUARRIED, METAL MINES AND NONMETALLIC MINERAL OPERATIONS, 1973-79

	Unit	1973	1974	1975	1976	1977	1978	1979
Metal mines[1]								
Ore mined	million tonnes	274.7	278.7	264.2	296.5	299.5	248.1	274.8
Man-hours paid[2]	million	98.4	104.0	102.4	100.6	101.2	84.9	85.1
Man-hours paid per tonne mined	number	0.36	0.37	0.39	0.34	0.34	0.34	0.31
Tonnes mined per man-hour paid	tonnes	2.79	2.68	2.58	2.95	2.96	2.92	3.23
Nonmetallic mineral operations[3]								
Ore mined and rock quarried	million tonnes	158.5	174.5	155.1	162.0	200.2	200.4	196.0
Man-hours paid[2]	million	26.2	27.9	23.4	26.9	27.7	26.3	27.8
Man-hours paid per tonne mined	number	0.17	0.16	0.15	0.17	0.14	0.13	0.14
Tonnes mined per man-hour paid	tonnes	6.05	6.25	6.63	6.02	7.23	7.62	7.05

[1] Excludes placer mining. [2] Man-hours paid for production and related workers only. [3] Includes asbestos, potash, gypsum and stone.

TABLE 41. CANADA, AVERAGE WEEKLY WAGES AND HOURS WORKED, HOURLY-RATED EMPLOYEES IN MINING, MANUFACTURING AND CONSTRUCTION INDUSTRIES, 1974-80

	1974	1975	1976	1977	1978	1979	1980P
Mining							
Average hours per week	40.4	40.0	40.3	40.6	40.5	41.1	40.8
Average weekly wage ($)	225.25	260.74	298.44	329.45	354.51	397.03	440.64
Metals							
Average hours per week	39.4	39.4	39.6	39.8	39.4	40.4	40.1
Average weekly wage ($)	222.80	260.33	296.21	325.75	344.94	387.84	424.26
Mineral fuels							
Average hours per week	40.6	39.7	40.6	41.3	41.0	40.8	41.2
Average weekly wage ($)	231.51	264.98	309.24	333.51	367.34	410.04	475.86
Nonmetals							
Average hours per week	41.1	40.1	40.5	40.3	40.5	40.3	39.5
Average weekly wage ($)	191.51	230.84	273.56	301.92	326.23	367.13	404.09
Manufacturing							
Average hours per week	38.9	38.6	38.7	38.7	38.8	38.8	38.5
Average weekly wage ($)	170.03	195.12	222.79	246.63	265.06	288.67	315.32
Construction							
Average hours per week	39.1	39.0	38.9	38.7	39.0	39.4	39.1
Average weekly wage ($)	251.08	293.96	330.95	378.50	400.58	434.98	473.11

Note: Wages reflect seasonally unadjusted figures.
P Preliminary.

TABLE 42. CANADA, AVERAGE WEEKLY WAGES OF HOURLY-RATED EMPLOYEES IN THE MINING INDUSTRY, IN CURRENT AND 1971 DOLLARS, 1974-80

	1974	1975	1976	1977	1978	1979	1980P
Current dollars							
All mining	222.25	260.74	298.44	329.45	354.51	397.03	440.64
Metals	222.80	260.33	296.21	325.75	344.94	387.84	424.26
Mineral fuels	231.51	264.98	309.24	333.51	367.34	410.04	475.86
Coal	212.56	243.01	274.00	303.53	323.49	364.41	430.73
Nonmetals except fuel	191.51	230.84	273.56	301.92	326.23	367.13	404.09
1971 dollars							
All mining	177.80	188.26	200.43	204.88	202.35	207.65	209.23
Metals	178.24	187.96	198.93	202.58	196.88	202.85	201.45
Mineral fuels	185.21	191.32	207.68	207.41	209.67	214.46	225.95
Coal	170.05	175.46	184.02	188.76	184.64	190.59	204.53
Industrial minerals	153.21	166.67	183.72	187.76	186.20	192.01	191.88

Note: Wages reflect seasonally unadjusted figures.
P Preliminary.

TABLE 43. CANADA, INDUSTRIAL FATALITIES PER THOUSAND WORKERS, BY INDUSTRY GROUPS 1978-80[1]

	Facilities (number)			Number of Workers (000)			Rate per 1,000 workers[2]		
	1978	1979	1980	1978	1979	1980	1978	1979	1980P
Agriculture	7	13	6	132.0	142.0	156.0	0.05	0.09	0.04
Forestry	85	106	67	66.6	70.2	68.2	1.28	1.51	0.98
Fishing	15	14	21	10.4	12.0	15.0	1.44	1.17	1.40
Mining	114	142	132	139.7	151.0	170.2	0.82	0.94	0.78
Manufacturing	182	165	117	1 803.6	1 873.9	1 851.2	0.10	0.09	0.06
Construction	165	179	149	436.3	465.0	455.1	0.38	0.38	0.33
Transportation	204	207	183	802.9	819.6	842.8	0.25	0.25	0.22
Trade	64	66	62	1 467.3	1 515.8	1 555.6	0.04	0.04	0.04
Finance	6	5	7	488.2	502.4	517.1	0.01	0.01	0.01
Service	55	73	71	2 544.5	2 656.4	2 766.5	0.02	0.03	0.03
Public administration	77	63	41	633.0	625.0	635.6	0.12	0.10	0.06
Unknown	17	21	15	..	..	..	..	..	..
Total	991	1,054	871	8 524.5	8 833.3	9 033.3	0.12	0.12	0.10

Note: See footnotes, Table 43.

[1] Includes fatalities resulting from occupational chest diseases such as silicosis, lung cancer, etc. [2] The rates may be understated because only 80 per cent of workers in the Statistics Canada employment estimates are covered by workers' compensation.

P Preliminary; .. Not available.

TABLE 44. CANADA, INDUSTRIAL FATALITIES PER THOUSAND WORKERS, BY INDUSTRY GROUPS, 1974–80

	1974	1975	1976	1977	1978	1979	1980P
Agriculture	0.27	0.10	0.13	0.11	0.05	0.09	0.04
Forestry	1.31	1.25	1.14	0.92	1.28	1.51	0.98
Fishing[1]	1.38	3.25	3.60	2.37	1.44	1.17	1.40
Mining[2]	1.52	1.20	1.18	0.92	0.82	0.94	0.78
Manufacturing	0.17	0.13	0.11	0.10	0.10	0.09	0.06
Construction	0.52	0.48	0.42	0.37	0.38	0.38	0.33
Transportation[3]	0.33	0.28	0.28	0.22	0.25	0.25	0.22
Trade	0.09	0.05	0.04	0.05	0.04	0.04	0.04
Finance[4]	0.02	0.01	0.02	0.02	0.01	0.01	0.01
Service[5]	0.05	0.04	0.03	0.03	0.02	0.03	0.03
Public administration	0.11	0.14	0.09	0.08	0.12	0.10	0.06
Total	0.18	0.15	0.13	0.11	0.12	0.12	0.10

[1] Includes trapping, hunting. [2] Includes quarrying and oil wells. [3] Includes storage, communication, electric power and water utilities and highway maintenance. [4] Includes insurance and real estate. [5] Includes community, business and personal service.
P Preliminary.

TABLE 45. CANADA, INDUSTRIAL FATALITIES BY OCCUPATIONAL INJURIES AND ILLNESSES, 1978–80P

	Occupational Injuries			Occupational Illnesses			Total		
	1978	1979	1980P	1978	1979	1980P	1978	1979	1980P
Agriculture	7	13	6	0	0	0	7	13	6
Forestry	85	106	66	0	0	1	85	106	67
Fishing	15	14	21	0	0	0	15	14	21
Mining	56	84	87	58	58	45	114	142	132
Manufacturing	146	136	97	36	29	20	182	165	117
Construction	160	173	142	5	6	7	165	179	149
Transportation	202	206	181	2	1	2	204	207	183
Trade	63	64	62	1	2	0	64	66	62
Finance	6	5	7	0	0	0	6	5	7
Service	53	69	70	2	4	1	55	73	71
Public administration	74	58	41	3	5	0	77	63	41
Unknown	17	20	13	-	1	2	17	21	15
Total	884	948	793	107	106	78	991	1 054	871

P Preliminary; - Nil.

TABLE 46. CANADA, NUMBER OF STRIKES AND LOCKOUTS BY INDUSTRIES, 1978-1980

	1978			1979			1980		
	Strikes and lockouts	Workers involved	Duration in person-days	Strikes and lockouts	Workers involved	Duration in person-days	Strikes and lockouts	Workers involved	Duration in person-days
Agriculture	1	4	20	1	12	10	1	30	900
Forestry	19	5,446	67,810	11	2,632	110,940	8	3,588	337,220
Fishing and trapping	1	600	1,200	-	-	-	2	16,082	395,870
Mines	39	31,147	1,699,460	40	28,396	1,586,360	33	21,400	418,270
Manufacturing	459	117,548	2,527,980	511	149,656	3,129,460	404	86,247	3,137,370
Construction	108	63,105	1,232,610	48	10,839	88,290	69	57,940	1,107,060
Transportation and utilities	126	74,332	945,480	129	79,933	1,181,580	106	27,329	729,070
Trade	91	10,618	245,950	78	16,442	247,410	109	7,855	218,550
Finance, insurance and real estate	16	924	7,520	18	2,164	38,110	20	1,238	47,710
Service	143	33,824	407,650	139	64,855	760,600	218	136,193	1,883,280
Public administration	55	64,140	257,140	74	58,845	642,740	58	83,123	700,090
Various industries	-	-	-	1	48,730	48,730	-	-	-
All industries	1,058	401,688	7,392,820	1 050	462,504	7,834,230	1,028	441,025	8,975,390

P Preliminary; - Nil.

TABLE 47. CANADA, NUMBER OF STRIKES AND LOCKOUTS BY MINING AND MINERAL MANUFACTURING, 1978-80

	1978			1979			1980P		
	Strikes and lockouts	Workers involved	Duration in person-days	Strikes and lockouts	Workers involved	Duration in person-days	Strikes and lockouts	Workers involved	Duration in person-days
Mines	39	31,147	1,699,460	40	28,396	1,586,360	33	21,400	418,270
Metal	16	23,711	1,521,540	17	18,861	1,506,980	18	10,749	189,570
Mineral fuels	10	3,983	39,640	8	7,717	55,010	5	7,486	99,450
Nonmetals	12	3,443	137,550	10	1,645	22,980	7	3,039	121,750
Quarries	1	10	730	5	173	1,390	3	126	7,500
Mineral manufacturing	59	21,108	310,130	73	25,080	1,126,900	52	10,086	530,620
Primary metals	24	17,838	215,400	30	17,929	924,150	18	5,212	321,530
Nonmetallic mineral products	31	2,480	92,020	41	5,875	185,870	31	3,208	123,310
Petroleum and coal products	4	790	2,710	2	1,276	16,880	3	1,666	85,780

P Preliminary.

TABLE 48. CANADA, SOURCE OF ORES HOISTED OR REMOVED FROM SELECTED TYPES OF MINES; 1977-79

Mines	1977			1978			1979		
	Under-ground	Open Pit	Total	Under-ground	Open Pit	Total	Under-ground	Open Pit	Total
					(kilotonnes)				
Asbestos	1 869	30 043	31 912	1 903	26 885	28 788	2 151	29 371	31 522
Copper-gold-silver	14 319	94 647	108 966	14 108	84 199	98 307	14 620	84 634	99 254
Gold-quartz	5 397	371	5 768	5 350	564	5 914	5 144	334	5 478
Gypsum	693	6 523	7 216	728	7 665	8 393	754	7 556	8 310
Iron Ore	2 987	124 070	127 057	3 550	92 773	96 323	3 641	127 158	130 799
Nickel-copper	19 137	1 258	20 395	10 224	1 082	11 306	8 950	1 233	10 183
Silver-lead-zinc	9 482	7 248	16 730	8 853	7 006	15 859	8 692	6 386	15 078
Uranium	3 899	1 115	5 014	5 306	820	6 126	5 408	733	6 141
Miscellaneous metals	1 462	14 137	15 599	1 245	12 976	14 221	1 212	6 610	7 822
Total	59 245	279 412	338 657	51 267	233 970	285 237	50 572	264 015	314 587
Percentage	17.5	82.5	100.0	18.0	82.0	100.0	16.0	84.0	100.0

TABLE 49. CANADA, ORE MINED AND ROCK QUARRIED IN THE MINING INDUSTRY, 1973-79

	1973	1974	1975	1976	1977	1978	1979
				(kilotonnes)			
Metals							
Gold-quartz	5 863	5 629	5 901	5 921	5 768	5 914	5 478
Copper-gold-silver	106 072	111 381	97 656	103 600	108 966	98 307	99 254
Silver-lead-zinc	15 363	14 295	16 169	14 309	16 730	15 859	15 078
Nickel-copper	23 168	25 302	23 265	21 462	20 395	11 306	10 183
Iron	108 622	107 105	101 482	133 073	127 057	96 323	130 799
Uranium	2 766	2 633	3 449	3 663	5 014	6 126	6 141
Miscellaneous metals	12 921	12 376	16 296	14 499	15 599	14 221	7 822
Total	274 775	278 721	264 218	296 527	299 528	248 056	274 755
Nonmetals							
Asbestos	32 949	34 524	22 186	31 055	31 912	28 788	31 522
Potash	16 037	21 945	21 713	20 277	24 813	24 856	25 511
Gypsum	7 619	6 917	5 578	5 978	7 216	8 393	8 310
Rock salt	4 105	4 291	3 627	5 080	4 974	5 050	5 639
Total	60 710	67 677	53 104	62 390	68 915	67 087	70 982
Structural materials							
Stone, all kinds quarried[1]	83 710	92 833	88 921	87 876	120 163	122 144	109 719
Stone used to make cement	14 941	14 948	13 654	13 350	12 614	13 051	17 860
Stone used to make lime	3 191	3 391	2 980	3 442	3 534	3 178	3 028
Total	101 842	111 172	105 555	104 668	136 310	138 373	130 607
Total ore mined and rock quarried	437 327	457 570	422 877	463 585	504 753	453 516	476 344

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[1] Excludes stone used to manufacture cement and lime.

TABLE 50. CANADA, EXPLORATION AND CAPITAL EXPENDITURES IN THE MINING INDUSTRY[1], BY PROVINCES AND TERRITORIES, 1978-80

		Capital						Repair						
		Construction												
		On-property exploration	On-property development	Structures	Total	Machinery and equipment	Total capital	Construction	Machinery and equipment	Total repair	Total capital and repair	Outside or general exploration	Land and mining rights	Total all expenditures
		($ million)												
Atlantic provinces	1978	1.2	20.0	12.6	33.8	59.5	93.3	8.5	110.5	119.0	212.3	17.6	1.0	230.9
	1979	2.2	47.0	27.7	76.9	51.4	128.3	10.4	173.2	183.6	311.9	21.1	0.6	333.6
	1980P	3.1	59.9	22.1	85.1	60.0	145.1	14.8	168.2	183.0	328.1	35.6	0.2	363.9
Quebec	1978	16.1	73.9	36.5	126.5	48.2	174.7	17.3	179.4	196.7	371.4	39.9	2.5	413.8
	1979	7.5	109.6	40.0	157.1	72.9	230.0	25.2	200.1	225.3	455.3	39.5	1.3	496.1
	1980P	15.5	153.9	75.8	245.2	98.7	343.9	43.8	273.5	317.3	661.2	52.7	9.8	723.7
Ontario	1978	7.8	121.0	47.5	176.3	85.9	262.2	18.6	169.2	187.8	450.0	21.0	(2)	(2)
	1979	6.4	150.7	68.2	225.3	127.2	352.5	23.2	221.6	244.8	597.3	18.4	0.9	616.6
	1980P	12.0	178.8	124.9	315.7	120.2	435.9	66.2	235.9	302.1	738.0	58.5	3.3	799.8
Manitoba	1978	(2)	(2)	(2)	45.9	28.1	74.0	2.0	25.9	27.9	101.9	11.8	(2)	(2)
	1979	(2)	(2)	(2)	46.8	15.9	62.7	(2)	34.2	(2)	96.9	11.8	-	108.7
	1980P	(2)	(2)	(2)	39.1	11.3	50.4	6.6	44.2	50.8	101.2	17.2	0.3	118.7
Saskatchewan	1978	(2)	(2)	(2)	58.6	78.5	137.1	5.7	58.6	64.3	201.4	27.9	1.7	231.0
	1979	4.9	29.3	40.0	74.2	66.9	141.1	5.6	76.8	82.4	223.5	52.6	8.1	284.2
	1980P	5.5	42.3	61.8	109.6	87.1	196.7	9.1	90.3	99.4	296.1	56.6	4.7	357.4
Alberta	1978	0.5	6.4	16.5	23.4	44.8	68.2	2.4	36.1	38.5	106.7	7.0	2.3	116.0
	1979	(2)	(2)	(2)	19.3	40.7	60.0	(2)	38.7	(2)	98.7	8.5	1.2	108.4
	1980P	(2)	(2)	(2)	34.5	41.8	76.3	1.2	57.5	58.7	135.0	14.2	(2)	(2)
British Columbia	1978	16.2	55.7	33.2	105.1	43.9	149.0	10.8	167.2	178.0	327.0	32.5	1.0	360.5
	1979	17.8	95.1	115.6	228.5	85.8	314.3	10.7	178.0	188.7	503.0	48.3	1.5	552.8
	1980P	34.0	150.6	302.9	487.5	233.3	720.8	21.8	232.6	254.4	975.2	89.0	3.7	1,067.9
Yukon and Northwest Territories	1978	5.3	13.6	6.3	25.2	16.8	42.0	6.6	29.8	36.4	78.4	37.2	0.3	115.9
	1979	5.6	11.3	10.2	27.1	23.4	50.5	5.7	46.0	51.7	102.2	48.7	18.6	169.5
	1980P	8.4	26.9	99.3	134.6	82.3	216.9	4.7	50.4	55.1	272.0	68.3	(2)	(2)
Canada	1978	54.1	345.1	195.6	594.8	405.7	1,000.5	71.9	776.7	848.6	1,849.1	194.9	13.3	2,057.3
	1979	49.2	476.3	329.7	855.2	484.2	1,339.4	84.8	964.6	1,049.4	2,388.8	248.9	32.2	2,669.9
	1980P	88.4	645.7	717.2	1,451.3	734.7	2,186.0	168.2	1,152.6	1,320.8	3,506.8	392.5	44.1	3,943.4

[1] Excludes the crude oil and natural gas industries and the smelting and refining industries; [2] Confidential, included in total.
P Preliminary; - Nil.

TABLE 51. CANADA, EXPLORATION AND CAPITAL EXPENDITURES[1] IN THE MINING INDUSTRY, BY TYPE OF MINING, 1978-1980

		Capital						Repair						
		Construction												
		On-property exploration	On-property development	Structures	Total	Machinery and equipment	Total capital	Construction	Machinery and equipment	Total repair	Total capital and repair	Outside or general exploration	Land and mining rights	Total, all expenditures
							($ million)							
Metal Mining														
Gold	1978	4.2	24.1	3.6	31.9	4.8	36.7	2.0	15.8	17.8	54.5	1.1	-	55.6
	1979	4.1	29.4	6.7	40.2	16.8	57.0	3.2	23.4	26.6	83.6	5.6	-	89.2
	1980P	24.4	62.3	35.8	122.5	38.2	160.7	6.8	27.9	34.7	195.4	16.7	(2)	(2)
Copper-gold-silver	1978	8.7	42.9	27.6	79.2	52.0	131.2	11.7	144.4	156.1	287.3	5.0	(2)	(2)
	1979	10.2	78.4	76.5	165.1	84.5	249.6	17.1	165.0	182.1	431.7	8.5	(2)	(2)
	1980P	24.1	93.4	187.4	304.9	185.9	490.8	24.2	211.0	235.2	726.0	8.2	(2)	(2)
Silver-lead-zinc	1978	7.2	19.0	16.2	42.4	19.9	62.3	5.6	33.0	38.6	100.9	3.1	(2)	(2)
	1979	8.1	20.3	25.8	54.2	33.4	87.6	5.2	43.8	49.0	136.6	6.2	18.5	161.3
	1980P	9.2	35.4	97.0	141.6	86.1	227.7	7.0	61.4	68.4	296.1	10.7	(2)	(2)
Iron	1978	(2)	(2)	(2)	71.1	32.5	103.6	17.7	196.0	213.7	317.3	(2)	-	(2)
	1979	(2)	81.4	15.4	96.8	40.3	137.1	27.5	268.4	295.9	433.0	(2)	-	(2)
	1980P	(2)	97.7	23.0	120.7	44.0	164.7	37.6	289.7	327.3	492.0	(2)	-	(2)
Other metal mining	1978	13.6	162.8	69.7	175.0	58.4	233.4	16.7	98.4	115.1	348.5	14.5	1.5	364.5
	1979	11.5	140.5	96.1	248.1	104.7	352.8	17.2	131.1	148.3	501.1	(2)	(2)	(2)
	1980P	14.6	178.8	214.2	407.6	109.3	516.9	60.1	169.1	229.2	746.1	(2)	1.4	(2)
Total metal mining	1978	33.7	248.8	117.1	399.6	167.6	567.2	53.7	487.6	541.3	1,108.5	(2)	2.4	(2)
	1979	(2)	383.9	220.5	604.4	279.7	886.1	70.2	631.7	701.9	1,586.0	29.8	19.7	1,635.5
	1980P	(2)	539.9	557.4	1,097.3	463.5	1,560.8	135.7	759.1	894.8	2,455.6	50.9	25.2	2,531.7
Nonmetal mining														
Asbestos	1978	1.5	43.9	26.6	72.0	31.0	103.0	5.8	88.3	94.1	197.1	(2)	(2)	(2)
	1979	0.5	49.7	19.0	69.2	29.7	98.9	5.6	93.8	99.4	198.3	0.4	(2)	(2)
	1980P	0.7	56.4	8.0	65.1	23.1	88.2	7.4	106.0	113.4	201.6	(2)	(2)	(2)
Other non-metal mining	1978	11.6	52.1	51.8	115.5	205.4	320.9	12.4	200.8	213.2	534.1	9.5	(2)	(2)
	1979	12.4	78.0	89.2	179.6	172.9	352.5	9.0	238.7	247.7	600.2	10.2	(2)	(2)
	1980P	11.1	121.6	148.6	281.3	244.5	525.8	25.1	287.2	312.3	838.1	(2)	(2)	(2)
Total non-metal mining	1978	13.1	96.0	78.4	187.5	236.4	423.9	18.2	289.1	307.3	731.2	(2)	6.5	(2)
	1979	12.9	127.7	108.2	248.8	202.6	451.4	14.6	232.5	247.1	798.5	10.6	10.0	819.1
	1980P	11.8	178.0	156.6	346.4	267.6	614.0	32.5	393.2	425.7	1,039.7	18.4	9.7	1,067.8
Metal and nonmetal exploration	1978	7.3	0.3	0.1	7.7	1.7	9.4	-	-	-	9.4	160.5	4.4	174.3
	1979	(2)	1.0	1.0	2.0	1.9	3.9	-	0.4	0.4	4.3	201.9	2.5	208.7
	1980P	(2)	4.4	3.2	7.6	3.6	11.2	-	0.3	0.3	11.5	323.2	9.2	343.9
Total mining	1978	54.1	345.1	195.6	594.8	405.7	1,000.5	71.9	776.7	848.6	1,849.1	194.9	13.3	2,057.3
	1979	49.2	476.3	329.7	855.2	484.2	1,339.4	84.8	964.6	1,049.4	2,388.8	248.9	32.2	2,669.9
	1980P	88.4	645.7	717.2	1,451.3	734.7	2,186.0	168.2	1,152.6	1,320.8	3,506.8	392.5	44.1	3,943.4

[1] Excludes expenditures in the petroleum and natural gas industries. (2) Confidential, included in total.
P Preliminary; - Nil.

TABLE 52. CANADA, DIAMOND DRILLING IN THE MINING INDUSTRY, BY MINING COMPANIES WITH OWN EQUIPMENT AND BY DRILLING CONTRACTORS, 1977-79

		1977			1978			1979		
		Exploration	Other	Total	Exploration	Other	Total	Exploration	Other	Total
						(metres)				
Metal mining										
Gold-quartz	Own equipment	9 579	5 557	15 136	12 410	2 544	14 954	13 455	-	13 455
	Contractors	138 704	21 803	160 507	154 703	39 678	194 381	170 711	14 789	185 500
	Total	148 283	27 360	175 643	167 113	42 222	209 335	184 166	14 789	198 955
Copper-gold-silver	Own equipment	100 082	1 158	101 240	97 698	292	97 990	141 220	-	141 220
	Contractors	221 166	17 357	238 523	161 075	18 000	179 075	133 445	10 713	144 158
	Total	321 248	18 515	339 763	258 773	18 292	277 065	274 665	10 713	285 378
Nickel-copper	Own equipment	150 924	319	151 243	63 910	-	63 910	109 799	-	109 799
	Contractors	24 774	-	24 774	5 747	-	5 747	42 385	-	42 385
	Total	175 698	319	176 017	69 657	-	69 657	152 184	-	152 184
Silver-lead-zinc and silver-cobalt	Own equipment	53 269	17 269	70 538	45 729	348 508	394 237	18 609	4 090	22 699
	Contractors	142 741	-	142 741	96 252	-	96 252	106 569	1 764	108 333
	Total	196 010	17 269	213 279	141 981	348 508	490 489	125 178	5 854	131 032
Iron mines	Own equipment	-	-	-	-	-	-	-	-	-
	Contractors	20 322	-	20 322	18 734	-	18 734	28 266	-	28 266
	Total	20 322	-	20 322	18 734	-	18 734	28 266	-	28 266
Uranium	Own equipment	13 387	-	13 387	17 503	-	17 503	23 509	-	23 509
	Contractors	48 638	-	48 638	40 174	914	41 088	45 255	3 269	48 524
	Total	62 025	-	62 025	57 677	914	58 591	68 764	3 269	72 033
Miscellaneous metal mining	Own equipment	-	-	-	-	-	-	4 629	-	4 629
	Contractors	41 982	-	41 982	57 872	-	57 872	45 090	-	45 090
	Total	41 982	-	41 982	57 872	-	57 872	49 719	-	49 719
Total metal mining	Own equipment	327 241	24 303	351 544	237 250	351 344	588 594	311 221	4 090	315 311
	Contractors	638 327	39 160	677 487	534 557	58 592	593 149	571 721	30 535	602 256
	Total	965 568	63 463	1 029 031	771 807	409 936	1 181 743	882 942	34 625	917 567

Nonmetal mining										
Asbestos	Own equipment	-	-	-	-	-	-	-	-	-
	Contractors	65 309	-	65 309	48 087	-	48 087	20 238	-	20 238
	Total	65 309	-	65 309	48 087	-	48 087	20 238	-	20 238
Gypsum	Own equipment	-	-	-	-	-	-	1 779	-	1 779
	Contractors	7 269	-	7 269	5 660	-	5 660	4 177	-	4 177
	Total	7 269	-	7 269	5 660	-	5 660	5 956	-	5 956
Salt	Own equipment	1 528	-	1 528	1 722	-	1 722	2 632	-	2 632
	Contractors	-	-	-	-	-	-	-	-	-
	Total	1 528	-	1 528	1 722	-	1 722	2 632	-	2 632
Miscellaneous nonmetal mining	Own equipment	2 245	-	2 245	2 480	-	2 480	1 958	-	1 958
	Contractors	-	-	-	294	-	294	671	-	671
	Total	2 245	-	2 245	2 774	-	2 774	2 629	-	2 629
Total nonmetal mining	Own equipment	3 773	-	3 773	4 202	-	4 202	6 369	-	6 369
	Contractors	72 578	-	72 578	54 041	-	54 041	25 086	-	25 086
	Total	76 351	-	76 351	58 243	-	58 243	31 455	-	31 455
Total mining industry	Own equipment	331 014	24 303	355 317	241 452	351 344	592 796	317 590	4 090	321 680
	Contractors	710 905	39 160	750 065	588 598	58 592	647 190	596 807	30 535	627 342
	Total	1 041 919	63 463	1 105 382	830 050	409 936	1 239 986	914 397	34 625	949 022

- Nil.

TABLE 53. CANADA, ORE MINED AND ROCK QUARRIED IN THE MINING INDUSTRY, 1950-79

	Metals	Nonmetal[1]	Total
		(million tonnes)	
1950	41.6	37.9	79.5
1951	44.2	39.7	83.9
1952	47.4	40.0	87.4
1953	49.3	42.8	92.1
1954	53.5	55.7	109.2
1955	62.7	57.6	120.3
1956	70.2	66.2	136.4
1957	76.4	74.5	150.9
1958	71.4	71.2	142.6
1959	89.9	82.2	172.1
1960	92.1	88.7	180.8
1961	90.1	96.7	186.8
1962	103.6	103.8	207.4
1963	112.7	120.4	233.1
1964	128.0	134.1	262.1
1965	151.0	146.5	297.5
1966	147.6	171.8	319.4
1967	169.1	177.5	346.6
1968	186.9	172.7	359.6
1969	172.0	178.8	350.8
1970	213.0	179.1	392.1
1971	211.5	185.8	397.3
1972	206.0	189.7	395.7
1973	274.8	162.6	437.3
1974	278.7	178.8	457.6
1975	264.2	158.7	422.9
1976	296.5	167.1	463.6
1977	299.5	205.2	504.8
1978	248.1	205.5	453.5
1979	274.8	201.6	476.3

[1] Includes nonmetallic mineral mining and all stone quarried, including stone used to make cement and lime. From 1973 onwards, coverage is the same as in Table 49.

TABLE 54. CANADA, TOTAL DIAMOND DRILLING, METAL DEPOSITS, 1950-79

	Gold-quartz deposits	Copper-gold-silver and nickel-copper deposits	Silver-lead-zinc and silver-cobalt deposits	Other metal bearing deposits[1]	Total metal deposits
			(metres)		
1950	1 109 553	1 243 801	434 587	83 214	2 871 155
1951	891 648	1 264 630	460 296	108 224	2 724 798
1952	808 245	1 187 024	456 146	56 032	2 507 447
1953	675 598	976 514	367 864	65 279	2 085 255
1954	737 266	826 288	271 873	199 097	2 034 524
1955	717 674	875 942	341 857	537 612	2 473 085
1956	682 600	1 490 298	399 679	383 431	2 956 008
1957	706 273	1 098 490	323 704	287 364	2 415 831
1958	546 861	923 026	297 792	286 970	2 054 649
1959	558 160	1 110 664	282 088	383 471	2 334 383
1960	628 016	1 267 792	226 027	315 067	2 436 902
1961	503 741	1 128 091	255 101	221 079	2 199 452
1962	902 288	1 025 048	350 180	358 679	2 636 195
1963	529 958	977 257	288 204	148 703	1 944 122
1964	458 933	709 588	401 099	104 738	1 674 358
1965	440 020	779 536	331 294	275 917	1 826 727
1966	442 447	729 148	292 223	164 253	1 628 071
1967	391 347	947 955	230 182	120 350	1 689 834
1968	375 263	935 716	198 038	56 780	1 565 797
1969	274 410	923 452	197 670	109 592	1 505 124
1970	214 717	1 132 915	375 019	99 373	1 822 024
1971	193 291	1 089 103	308 798	83 851	1 675 043
1972	229 771	967 640	240 195	50 225	1 487 831
1973	243 708	713 134	185 946	57 730	1 200 518
1974	250 248	798 564	197 322	83 484	1 329 618
1975	216 158	532 991	184 203	97 971	1 031 323
1976	156 030	507 620	166 366	97 735	927 751
1977	175 643	515 780	213 279	124 329	1 029 031
1978	209 335	227 065	490 489	135 197	1 181 743
1979	198 955	437 562	131 032	150 018	917 567

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[1] Includes iron, titanium, uranium, molybdenum and other metal deposits.

TABLE 55. CANADA, EXPLORATION DIAMOND DRILLING, METAL DEPOSITS, 1950-79

	Mining companies with own personnel and equipment	Diamond drill contractors	Total
		(metres)	
1950	241 026	1 046 798	1 287 824
1951	368 015	1 102 260	1 470 275
1952	416 467	951 104	1 367 571
1953	318 970	872 668	1 191 638
1954	295 613	1 109 844	1 405 457
1955	464 118	1 546 025	2 010 143
1956	474 562	1 644 735	2 119 297
1957	358 300	1 233 323	1 591 623
1958	237 133	1 200 625	1 437 758
1959	239 786	1 367 061	1 606 847
1960	268 381	1 409 416	1 677 797
1961	302 696	1 337 173	1 639 869
1962	167 214	1 748 023	1 915 237
1963	361 180	1 169 292	1 530 472
1964	143 013	1 072 985	1 215 998
1965	209 002	1 176 996	1 385 998
1966	163 379	1 044 860	1 208 239
1967	93 164	1 123 137	1 216 301
1968	159 341	990 690	1 150 031
1969	135 311	1 072 328	1 207 639
1970	62 147	1 228 061	1 290 208
1971	86 838	1 053 330	1 140 168
1972	251 651	839 753	1 091 404
1973	321 333	742 899	1 064 232
1974	357 823	892 557	1 250 380
1975	346 770	618 161	964 931
1976	335 919	532 036	867 955
1977	327 241	638 327	965 568
1978	237 250	534 557	771 807
1979	311 221	571 721	882 942

See footnotes to Table 54.

TABLE 56. CANADA, DIAMOND DRILLING, OTHER THAN FOR EXPLORATION, METAL DEPOSITS, 1950-79

	Mining companies with own personnel and equipment	Diamond drill contractors	Total
		(metres)	
1950	..	..	1 583 331
1951	..	..	1 254 523
1952	..	..	1 139 876
1953	..	..	893 617
1954	..	..	629 067
1955	410 925	52 017	462 942
1956	790 522	46 188	836 710
1957	524 724	156 060	680 784
1958	444 376	172 516	616 892
1959	488 783	238 753	727 536
1960	450 246	308 860	759 105
1961	384 432	175 149	559 581
1962	528 700	192 259	720 959
1963	388 228	25 422	413 650
1964	385 765	72 594	458 359
1965	393 947	46 822	440 769
1966	227 968	191 863	419 831
1967	186 463	287 071	473 534
1968	122 851	292 914	415 765
1969	87 552	209 933	297 485
1970	290 363	241 453	531 816
1971	295 966	238 910	534 876
1972	304 523	91 903	396 426
1973	77 162	59 124	136 286
1974	54 353	24 885	79 238
1975	31 917	34 475	66 392
1976	31 413	28 383	59 796
1977	24 303	39 160	63 463
1978	351 344	58 592	409 936
1979	4 090	30 535	34 625

The total footage drilled shown in Tables 55 and 56 equals the total footage drilled reported in Table 54. Nonproducing companies excluded since 1964.

.. Not available.

TABLE 57. CANADA, CRUDE MINERALS TRANSPORTED BY CANADIAN RAILWAYS, 1977-79

	1977	1978	1979
		(000 tonnes)	
Metallic minerals			
Alumina and bauxite	2 585	2 682	1 973
Copper ores and concentrates	2 220	1 963	1 696
Iron ores and concentrates	57 288	42 595	62 343
Iron pyrite	24	10	14
Lead ores and concentrates	625	695	941
Lead-zinc ores and concentrates	41	41	1
Manganese ores	10	8	10
Nickel-copper ores and concentrates	5 214	3 479	2 626
Nickel ores and concentrates	1 172	571	145
Tungsten ores and concentrates	2	2	2
Zinc ores an concentrates	2 143	1 882	1 704
Metallic ores and concentrates, nes	43	82	58
Total metallic minerals	71 367	54 010	71 513
Nonmetallic minerals			
Abrasives, natural	69	57	90
Asbestos	790	699	594
Barite	63	61	87
Clay	621	705	682
Gravel	928	139	145
Gypsum	4 359	4 876	4 905
Limestone, agricultural	83	68	74
Limestone, industrial	311	339	400
Limestone, nes	3 196	3 581	3 725
Nepheline syenite	402	397	406
Phosphate rock	1 884	2 294	2 634
Potash (KCl)	8 719	9 690	10 560
Refractory materials, nes	14	10	3
Salt, rock	986	818	906
Salt, nes	157	141	147
Sand, industrial	1 277	1 262	1 182
Sand, nes	41	25	20
Silica	18	23	24
Sodium carbonate	390	629	566
Sodium sulphate	459	459	540
Stone, building, rough	16	10	13
Stone, nes	487	400	420
Sulphur, liquid	1 340	1 384	1 517
Sulphur, nes	3 295	4 009	4 571
Nonmetallic minerals, nes	295	176	175
Total nonmetallic minerals	30 200	32 252	34 386
Mineral fuels			
Coal, anthracite	180	185	160
Coal, bituminous	17 968	20 331	20 450
Coal, lignite	1 124	603	329
Coal, nes	6	7	11
Natural gas and other crude bituminous substances	19	15	20
Oil, crude	283	291	293
Total mineral fuels	19 580	21 432	21 263
Total crude minerals	121 147	107 694	127 162
Total revenue freight moved by Canadian railways	247 247	238 824	257 874
Per cent crude minerals of total revenue freight	49.0	45.1	49.3

nes Not elsewhere specified.

TABLE 58. CANADA, CRUDE MINERALS TRANSPORTED BY CANADIAN RAILWAYS, 1950-79

	Total Revenue Freight	Total Crude Minerals	Crude Minerals as % of Revenue Freight		Total Revenue Freight	Total Crude Minerals	Crude Mineral as % of Revenue Freight
	(million tonnes)				(million tonnes)		
1950	130.8	47.0	35.9	1965	186.2	80.9	43.5
1951	146.3	47.6	32.5	1966	194.5	80.6	41.5
1952	147.1	45.9	31.2	1967	190.0	81.2	42.7
1953	141.7	44.7	31.5	1968	195.4	86.7	44.4
1954	129.8	45.0	34.6	1969	189.0	81.9	43.4
1955	152.2	61.2	40.2	1970	211.6	97.5	46.1
1956	172.0	68.7	39.9	1971	214.5	95.6	44.6
1957	157.9	64.2	40.6	1972	215.8	89.4	41.4
1958	139.2	52.4	37.6	1973	241.2	113.1	46.9
1959	150.6	62.8	41.7	1974	246.3	115.3	46.8
1960	142.8	57.1	39.9	1975	226.0	110.6	49.0
1961	138.9	54.1	38.9	1976	238.5	116.6	48.9
1962	146.0	60.3	41.3	1977	247.2	121.1	49.0
1963	154.6	62.9	40.7	1978	238.8	107.7	45.1
1964	180.0	74.6	41.5	1979	257.8	127.2	49.3

TABLE 59. CANADA, FABRICATED MINERAL PRODUCTS TRANSPORTED BY CANADIAN RAILWAYS, 1977-79

	1977	1978	1979
		(000 tonnes)	
Metallic mineral products			
Ferrous mineral products			
Ferroalloys	129	129	100
Pig iron	63	87	70
Ingots, blooms, billets, slabs of iron and steel	258	338	577
Other primary iron and steel	38	36	133
Castings and forgings, iron and steel	237	253	207
Bars and rods, steel	654	837	905
Plates, steel	341	442	566
Sheet and strip, steel	1 114	1 137	1 164
Structural shapes and sheet piling, iron and steel	332	421	469
Rails and railway track material	132	91	92
Pipes and tubes, iron and steel	401	461	550
Wire, iron or steel	35	49	46
Iron and steel scrap	1 458	1 806	2 018
Slag, dross, etc.	99	97	107
Total ferrous mineral products	5 291	6 184	7 004
Nonferrous mineral products			
Aluminum paste, powder, pigs, ingots, shot	118	212	81
Aluminum and aluminum alloy fabricated material, nes	278	250	278
Copper matte and precipitates	2	1	3
Copper and alloys, in primary form	436	396	374
Copper and alloys, nes	69	60	66
Lead and alloys	162	156	143
Nickel and nickel-copper matte	137	92	85
Nickel and alloys	34	28	28
Tin and alloys	4	1	-
Zinc and alloys	395	444	417
Other nonferrous base metals and alloys	11	28	22
Nonferrous metal scrap	87	116	114
Total nonferrous mineral products	1 733	1 784	1 611
Total metallic mineral products	7 024	7 968	8 615
Nonmetallic mineral products			
Natural stone basic products, chiefly structural	200	221	226
Bricks and tiles, clay	57	52	50
Fire brick and similar shapes	117	107	134
Dolomite and magnesite, calcined	82	72	81
Refractories, nes	33	30	32
Glass basic products	140	108	105
Asbestos and asbestos-cement basic products	20	27	27
Portland cement, standard	1 931	2 006	1 882
Concrete pipe	38	33	35
Cement and concrete basic products, nes	378	405	551
Plaster	25	18	19
Gypsum wallboard and sheathing	62	68	36
Gypsum basic products, nes	2	7	4
Lime, hydrated and quick	441	454	488
Nonmetallic mineral basic products, nes	747	817	638
Fertilizers and fertilizer materials, nes	1 952	2 139	2 183
Total nonmetallic mineral products	6 225	6 564	6 491

(continued on following page)

TABLE 59. (cont'd)

	1977	1978	1979
		(000 tonnes)	
Mineral fuel products			
Gasoline	1 773	1 720	1 601
Aviation turbine fuel	87	67	66
Diesel fuel	3 216	3 053	3 009
Kerosene	5	6	8
Fuel oil, nes	1 220	1 108	1 115
Lubricating oils and greases	373	412	404
Petroleum coke	516	656	613
Coke, nes	938	951	852
Refined and manufactured gases, fuel type	3 146	2 606	2 818
Asphalts and road oils	124	269	274
Bituminous pressed or molded fabricated material	2	2	1
Other petroleum and coal products	1 034	821	697
Total mineral fuel products	12 434	11 671	11 458
Total fabricated mineral products	25 683	26 203	26 564
Total revenue freight moved by Canadian railways	247 247	238 824	257 129
Fabricated mineral products as a percentage of total revenue freight	10.4	11.0	10.3

nes Not elsewhere specified.

TABLE 60. CANADA, CRUDE AND FABRICATED MINERALS TRANSPORTED THROUGH THE ST. LAWRENCE SEAWAY, 1978-80

	Montreal-Lake Ontario Section			Welland Canal Section		
	1978	1979	1980P	1978	1979	1980P
	(tonnes)					
Crude minerals						
Coal	853 116	455 325	204 715	4 906 242	7 067 442	6 616 010
Iron ore	12 285 257	13 441 896	9 993 769	14 224 586	13 714 946	10 358 099
Aluminum ores and concentrates	118 750	161 999	112 581	118 750	161 999	112 581
Clay and bentonite	16 987	237 380	250 526	16 963	237 380	250 526
Gravel and sand	13 759	28 090	34 000	76 930	284 152	195 676
Petroleum, crude	-	11 254	-	-	11 254	3 515
Stone, ground or crushed	96 478	335 378	163 545	1 193 433	1 379 422	1 046 175
Stone, rough	3 844	3 796	167	5 145	2 114	167
Salt	677 651	756 422	709 809	1 258 237	1 354 097	1 286 050
Phosphate rock	49 776	75 225	38 036	17	27 243	75
Sulphur	6 544	138 700	142 592	6 544	138 700	142 592
Other crude minerals	934 746	762 041	598 101	893 031	471 808	475 227
Total crude minerals	15 056 908	16 407 506	12 247 841	22 699 878	24 850 557	20 486 693
Fabricated mineral products						
Coke	2 255 841	2 103 300	1 271 222	2 291 341	2 270 269	1 301 705
Gasoline	98 778	171 284	202 471	95 488	210 704	157 557
Fuel oil	1 712 743	2 110 957	1 418 321	826 258	1 519 327	1 510 057
Lubricating oils and greases	131 876	67 394	83 667	133 304	60 393	83 605
Other petroleum products	206 369	139 244	139 139	122 273	98 147	83 453
Tar, pitch and creosote	29 315	27 352	46 573	44 882	32 111	26 822
Pig iron	219 923	120 302	183 667	209 830	111 350	174 772
Iron and steel: bars, rods, slabs	327 412	206 007	159 477	301 982	196 935	107 989
Iron and steel: nails, wire	35 290	23 907	7 284	32 985	22 799	6 657
Iron and steel: manufactured	2 939 135	2 589 384	1 724 459	2 790 274	2 400 906	1 072 857
Scrap iron and steel	580 443	524 197	689 676	535 990	494 846	611 508
Cement	20 873	20 817	82 864	374 402	522 117	268 433
Total fabricated minerals	8 557 998	8 104 145	6 008 820	7 759 009	7 939 904	5 405 415
Total crude and fabricated minerals	23 614 906	24 511 651	18 256 661	30 458 887	32 790 461	25 892 108
Total all products	51 657 530	50 187 359	42 142 459	59 575 722	60 023 466	54 073 636
Crude and fabricated minerals as a per cent of total	45.7	48.8	43.3	51.1	54.6	47.9

- Nil.

TABLE 61. CANADA, CRUDE MINERALS LOADED AND UNLOADED IN COASTWISE SHIPPING, 1979

	Loaded				Unloaded			
	Atlantic	Great Lakes	Pacific	Total	Atlantic	Great Lakes	Pacific	Total
	(tonnes)							
Metallic minerals								
Aluminum and bauxite ores	10 377	-	-	10 377	-	10 377	-	10 377
Copper ore and concentrates	33 828	-	-	33 828	33 828	-	-	33 828
Iron ore and concentrates	5 260 943	2 719 739	-	8 340 682	1 753 211	6 587 471	-	8 340 682
Titanium ore	980 531	-	-	980 531	980 531	-	-	980 531
Zinc ore and concentrates	45 142	-	20 464	65 805	45 142	-	20 464	65 606
Ores and concentrates, nes	92	-	1 468	1 560	92	-	1 468	1 560
Iron and steel scrap	13 442		3 359	16 801	13 442	-	3 359	16 801
Total metals	6 704 355	2 719 739	25 291	9 449 385	2 826 246	6 597 848	25 291	9 449 385
Nonmetallic minerals								
Bentonite	14 599	-	-	14 599	14 599	-	-	14 599
Dolomite	-	77 144	-	77 144	77 144	-	-	77 144
Gypsum	773 220	-	30 660	803 880	575 708	197 512	30 660	803 880
Limestone	6 436	2 408 574	1 079 920	3 494 930	6 436	2 408 574	1 079 920	3 494 930
Phosphate rock	21 071	-	-	21 071	21 071	-	-	21 071
Salt	407 270	1 228 329	53 804	1 689 403	1 121 999	513 600	53 804	1 689 403
Sand and gravel	280 064		2 940 735	3 220 799	280 064		2 940 735	3 220 799
Stone, crude, nes	-	436 010	51 757	487 767	42 006	394 004	51 757	487 767
Sulphur in ores	16 619	10 744	4 737	32 100	27 363		4 737	32 100
Crude nonmetallic minerals, nes	3 236	-	-	3 236	1 220	2 016	-	3 236
Total nonmetals	1 552 515	4 160 801	4 161 613	9 844 929	2 167 610	3 515 706	4 161 613	9 844 929
Mineral fuels								
Coal, bituminous	446 457	2 193 513	77 856	2 717 826	78 464	2 638 543	819	2 717 826
Oil, crude	70 651	-	46 727	117 378	117 378	-	-	117 378
Total mineral fuels	517 108	2 193 513	124 583	2 835 204	195 842	2 638 543	819	2 835 204
Total crude minerals	8 743 978	9 074 053	4 311 487	22 129 518	5 189 698	12 752 097	4 187 723	22 129 518
Total, all commodities	21 508 725	26 392 324	31 049 203	78 950 252	28 131 608	19 893 205	30 925 439	78 950 252
Crude minerals as a per cent of all commodities	40.7	34.4	13.9	28.0	18.4	64.1	13.5	28.0

- Nil.

TABLE 62. CANADA, CRUDE MINERALS LOADED AND UNLOADED AT CANADIAN PORTS IN INTERNATIONAL SHIPPING TRADE, 1977-79

	1977		1978		1979	
	Loaded	Unloaded	Loaded	Unloaded	Loaded	Unloaded
				(tonnes)		
Metallic minerals						
Alumina, bauxite ore	21 470	3 705 030	-	3 388 740	-	2 981 940
Copper ores and concentrates	816 235	-	678 868	35 208	709 050	-
Iron ore and concentrates	44 229 617	2 654 560	33 519 200	5 415 103	49 187 843	6 408 111
Lead ore and concentrates	97 693	15 571	98 224	-	118 655	-
Manganese ore	77 593	175 454	9 079	277 525	16 147	78 015
Nickel-copper ore and concentrates	108 219	29 548	44 685	18 517	64 568	624
Titanium ore	104 106	-	112 601	-	89 294	-
Zinc ore and concentrates	897 889	-	890 239	-	1 026 594	800
Ores and concentrates, nes	51 233	157 609	89 760	132 765	39 969	121 416
Iron and steel scrap	141 599	465	454 632	1 344	327 879	-
Nonferrous metal scrap	3 558	-	10 197	46	1 910	3 172
Slag, dross, residue	596 311	43 261	667 367	43 761	485 618	45 315
Total metals	47 145 523	6 781 498	36 574 852	9 313 009	52 067 527	9 639 393
Nonmetallic minerals						
Asbestos	269 620	2 313	316 566	1 637	453 339	306
Barite	74 569	-	46 950	-	1 981	3 625
Bentonite	-	259 813	9 551	155 331	-	294 799
China clay	-	32 428	-	45 463	-	48 321
Clay materials, nes	166	36 182	54	30 137	58 656	23 309
Dolomite	874 670	-	1 143 594	14 154	1 032 139	-
Fluorspar	10 990	122 477	9 979	214 974	23 567	143 842
Gypsum	4 940 953	16 419	5 472 451	112 536	5 505 915	147 189
Limestone	899 270	2 890 795	1 111 317	2 896 475	239 852	2 953 876
Phosphate rock	-	1 281 826	27 497	1 420 347	16	1 515 346
Potash (KCl)	1 397 449	18 623	1 717 967	27 297	2 703 604	-
Salt	1 282 034	950 145	1 590 162	968 154	1 649 916	899 917
Sand and gravel	11 641	1 264 920	233 535	1 297 394	38 959	884 694
Stone, crude, nes	41 415	13 339	74 656	9 771	118 508	36 307
Stone, crushed	-	-	18	-	-	33 290
Sulphur	2 649 403	12 031	2 412 609	5 171	3 287 497	4 990
Crude, nonmetallic minerals, nes	109 877	29 587	65 871	10 361	67 671	183
Total nonmetals	12 562 057	6 930 898	14 232 777	7 209 202	15 181 620	6 989 994

Mineral fuels						
Coal bituminous	9 952 375	15 302 598	11 087 496	13 443 184	12 328 621	17 178 491
Coal, nes	-	297 743	-	247 295	-	197 976
Oil, crude	597 273	16 402 728	395 850	15 772 012	107 231	16 188 498
Total fuels	10 549 648	32 003 069	11 483 346	29 462 491	12 435 852	33 564 965
Total crude minerals	70 257 228	45 715 465	62 290 975	45 984 702	79 684 999	50 194 352
Total, all commodities	119 770 049	58 882 220	116 521 506	61 792 786	134 638 829	67 414 437
Crude minerals as a per cent of all commodities	58.6	77.6	53.5	74.4	59.2	74.5

- Nil; nes - Not elsewhere specified.

TABLE 63. CANADA, FABRICATED MINERAL PRODUCTS LOADED AND UNLOADED AT CANADIAN PORTS IN INTERNATIONAL SHIPPING TRADE, 1977-79

	1977		1978		1979	
	Loaded	Unloaded	Loaded	Unloaded	Loaded	Unloaded
	(tonnes)					
Metallic products						
Aluminum	248 141	5 183	392 695	1 729	215 076	16 385
Copper and alloys	89 210	4 173	50 449	5 401	37 055	9 023
Ferroalloys	32 087	50 669	807	36 607	29 986	65 092
Iron and steel, primary	70 719	52 927	161 838	41 513	78 164	15 224
Iron, pig	439 057	7 418	505 384	2 562	221 359	19 350
Iron and steel, other						
bars and rods	20 411	199 474	16 818	126 638	17 545	214 058
castings and forgings	15 657	39 756	283	6 372	13 370	21 815
pipes and tubes	12 331	101 059	17 955	44 616	16 346	49 799
plates and sheet	174 364	327 742	106 243	249 725	108 606	490 158
rails and track material	27 651	6 606	78 051	4 877	76 751	12 198
structural shapes	51 943	226 255	58 569	301 058	69 596	342 272
wire	2 773	13 438	1 774	7 591	859	6 252
Lead and alloys	34 922	2	19 224	3	25 225	-
Nickel and alloys	2 982	998	1 562	515	2 212	915
Zinc and alloys	56 632	8 219	100 046	1 070	73 428	50
Nonferrous metals, nes	1 274	5 960	9 708	5 740	6 279	11 049
Metal fabricated basic products	7 218	18 501	7 135	20 755	6 713	11 682
Total metals	1 287 372	1 068 380	1 528 541	856 772	998 570	1 285 322
Nonmetallic products						
Asbestos basic products	937	77	28	-	1 642	-
Building brick, clay	2	178	-	-	4	59
Bricks and tiles, nes	9 259	5 533	9 342	6 654	23 876	12 410
Cement	1 069 330	61 425	1 542 891	137 458	2 829 351	61 244
Cement basic products	2 684	1 133	4 573	511	439	57
Drain tiles and pipes	-	5	-	30	-	-
Glass basic products	2 001	5 864	1 947	4 540	1 151	1 893
Lime	4 292	463	4 022	-	1 697	-
Nonmetallic mineral basic products	6 102	6 776	5 996	12 709	10 359	24 969
Fertilizers, nes	130 759	185 974	142 277	271 472	144 528	286 157
Total nonmetals	1 225 366	267 428	1 711 076	433 374	3 013 047	386 789

Mineral fuel products						
Asphalts, road oils	169	16 439	27	2 635	129	14 475
Coal tar, pitch	64	81 104	4 169	69 322	13 004	69 959
Coke	233 622	873 014	169 401	680 497	740 027	1 085 687
Fuel oil	2 596 932	1 612 211	3 363 319	1 559 443	3 710 585	1 858 914
Gasoline	362 460	432	540 964	4 237	385 648	26 638
Lubricating oils and greases	571	20 403	708	22 590	1 683	9 446
Petroleum and coal products, nes	272 044	94 336	238 157	119 924	38 048	71 274
Total fuels	3 465 862	2 697 939	4 316 745	2 458 648	4 889 124	3 136 393
Total fabricated mineral products	5 978 600	4 033 747	7 556 362	3 748 794	8 900 741	4 808 504
Total, all commodities	119 770 049	58 882 220	116 521 506	61 792 786	134 638 829	67 414 437
Fabricated mineral products as a per cent of all commodities	5.0	6.9	6.5	6.1	6.6	7.1

- Nil; nes Not elsewhere specified.

TABLE 64A. CANADA, FINANCIAL STATISTICS OF CORPORATIONS IN THE MINING INDUSTRY[1], BY DEGREE OF NON-RESIDENT OWNERSHIP, 1978

	Corporations		Assets		Equity		Sales		Profits		Taxable Income	
	(number)	(%)	($million)	(%)	($million)	(%)	($million)	(%)	($million)	(%)	($million)	(%)
Metal mines												
Reporting corporations												
Canadian	64	50.3	9,305	64.2	4,808	62.4	3,652	57.0	968	75.3	228	71.0
Foreign	44	34.7	5,193	35.8	2,891	37.6	2,757	43.0	317	24.7	93	29.0
Unclassified	19	15.0	1	--	--	--	--	--	--	--	--	--
Total, all corporations	127	100.0	14,499	100.0	7,699	100.0	6,409	100.0	1,285	100.0	321	100.0
Mineral fuels												
Reporting corporations												
Canadian	419	46.4	10,974	47.5	5,869	49.7	3.038	28.1	1,048	34.2	217	12.7
Foreign	212	23.5	12,113	52.4	6,183	51.4	7,736	71.7	2,014	65.7	1,482	87.1
Unclassified	272	30.1	22	0.1	-10	-0.1	16	0.2	2	0.1	3	0.2
Total, all corporations	903	100.0	23,109	100.0	12,042	100.0	10,790	100.0	3,064	100.0	1,702	100.0
Other mining (including mining services)												
Reporting corporations												
Canadian	1,160	35.7	2,863	49.7	1,141	43.6	1,519	47.4	154	32.5	112	33.1
Foreign	208	6.4	2,742	47.7	1,469	56.1	1,555	48.6	315	67.2	211	63.2
Unclassified	1,884	57.9	150	2.6	7	0.3	128	4.0	1	0.3	12	3.7
Total, all corporations	3,252	100.0	5,755	100.0	2,617	100.0	3,202	100.0	470	100.0	335	100.0
Total mining												
Reporting corporations												
Canadian	1,643	38.4	23,141	53.4	11,818	52.9	8,208	40.2	2,169	45.0	557	23.6
Foreign	464	10.8	20,048	46.2	10,543	47.2	12,048	59.1	2,646	54.9	1,786	75.8
Unclassified	2,175	50.8	174	0.4	-4	--	145	0.7	4	0.1	15	0.6
Total, all corporations	4,282	100.0	43,363	100.0	22,357	100.0	20,401	100.0	4,819	100.0	2,358	100.0

TABLE 64B. CANADA, FINANCIAL STATISTICS OF CORPORATIONS IN THE MINING INDUSTRY[1], BY DEGREE OF NON-RESIDENT OWNERSHIP, 1979

	Corporations		Assets		Equity		Sales		Profits		Taxable Income	
	(number)	(%)	($million)	(%)	($million)	(%)	($million)	(%)	($million)	(%)	($million)	(%)
Metal mines												
Reporting corporations												
Canadian	60	49.6	11,217	65.4	5,999	64.1	5,128	56.3	1,958	65.2	648	71.4
Foreign	41	33.9	5,940	34.6	3,359	35.9	3,988	43.7	1,046	34.8	260	28.6
Unclassified	20	16.5	2	--	1	--	--	--	--	--	--	--
Total, all corporations	121	100.0	17,159	100.0	9,359	100.0	9,116	100.0	3,004	100.0	908	100.0
Mineral fuels												
Reporting corporations												
Canadian	457	49.1	12,832	41.2	5,919	38.2	3,605	21.8	1,410	28.2	189	8.7
Foreign	205	22.0	18,265	58.7	9,583	61.8	12,886	78.1	3,573	71.7	1,973	91.9
Unclassified	268	28.8	22	0.1	-4	--	15	0.1	2	0.1	3	0.2
Total, all corporations	930	100.0	31,119	100.0	15,498	100.0	16,506	100.0	4,985	100.0	2,165	100.0
Other mining (including mining services)												
Reporting corporations												
Canadian	1,388	39.0	3,810	51.0	1,563	47.4	2,021	48.6	273	39.1	149	31.2
Foreign	195	5.5	3,507	46.9	1,749	53.0	1,996	48.0	426	60.8	312	65.6
Unclassified	1,975	55.5	155	2.1	-12	-0.4	142	3.4	1	0.1	15	3.2
Total, all corporations	3,558	100.0	7,472	100.0	3,300	100.0	4,159	100.0	701	100.0	476	100.0
Total mining												
Reporting corporations												
Canadian	1,905	41.3	27,860	50.0	13,481	47.9	10,754	36.1	3,642	41.9	986	27.7
Foreign	441	9.6	27,711	49.7	14,692	52.2	18,869	63.4	5,044	58.1	2,545	71.7
Unclassified	2,263	49.1	179	0.3	-16	-0.1	158	0.5	3	--	18	0.6
Total, all corporations	4,609	100.0	55,750	100.0	28,157	100.0	29,781	100.0	8,689	100.0	3,549	100.0

Note: Footnotes for Table 65 apply to this table. Figures may not add to totals due to rounding.

[1] Classification of the industry is the same as in Table 27.

-- Amount too small to be expressed.

TABLE 65A. CANADA, FINANCIAL STATISTICS OF CORPORATIONS IN THE MINERAL MANUFACTURING INDUSTRIES[1], BY DEGREE OF NON-RESIDENT OWNERSHIP, 1978

	Corporations[2]		Assets[4]		Equity[5]		Sales[6]		Profits[7]		Taxable Income[8]	
	(number)	(%)	($million)	(%)	($million)	(%)	($million)	(%)	($million)	(%)	($million)	(%)
Primary metal products												
Reporting corporations[2]												
Canadian	227	54.6	8,188	85.9	3,685	82.6	7,637	82.7	742	82.5	159	58.3
Foreign	48	11.5	1,330	14.0	769	17.3	1,578	17.1	156	17.4	113	41.1
Unclassified[3]	141	33.9	13	0.1	3	0.1	21	0.2	1	0.1	2	0.6
Total, all corporations	416	100.0	9,531	100.0	4,457	100.0	9,236	100.0	899	100.0	274	100.0
Nonmetallic mineral products												
Reporting corporations[2]												
Canadian	649	46.2	1,273	26.9	479	22.9	1,531	37.0	107	32.1	85	36.8
Foreign	108	7.7	3,405	71.9	1,593	76.5	2,518	60.9	226	67.6	142	61.7
Unclassified[3]	649	46.2	56	1.2	12	0.6	85	2.1	1	0.3	3	1.5
Total, all corporations	1,406	100.0	4,734	100.0	2,084	100.0	4,134	100.0	334	100.0	230	100.0
Petroleum and coal products												
Reporting corporations[2]												
Canadian	27	51.9	3,234	20.5	1,890	21.6	2,029	11.8	259	16.1	95	11.8
Foreign	14	26.9	12,573	79.5	6,846	78.4	15,222	88.2	1,348	83.9	707	88.2
Unclassified[3]	11	21.2	1	--	--	--	1	--	--	--	--	--
Total, all corporations	52	100.0	15,808	100.0	8,736	100.0	17,252	100.0	1,607	100.0	802	100.0
Total mineral manufacturing industries												
Reporting corporations[2]												
Canadian	903	48.2	12,695	42.2	6,054	39.6	11,197	36.6	1,108	39.0	339	26.0
Foreign	170	9.1	17,308	57.6	9,208	60.3	19,318	63.1	1,730	60.9	962	73.7
Unclassified[3]	801	42.7	70	0.2	15	0.1	107	0.3	2	0.1	5	0.4
Total, all corporations	1,874	100.0	30,073	100.0	15,277	100.0	30,622	100.0	2,840	100.0	1,306	100.0

TABLE 65B. CANADA, FINANCIAL STATISTICS OF CORPORATIONS IN THE MINERAL MANUFACTURING INDUSTRIES[1], BY DEGREE OF NON-RESIDENT OWNERSHIP, 1979

	Corporations[2]		Assets[4]		Equity[5]		Sales[6]		Profits[7]		Taxable Income[8]	
	(number)	(%)	($million)	(%)	($million)	(%)	($million)	(%)	($million)	(%)	($million)	(%)
Primary metal products												
Reporting corporations[2]												
Canadian	246	57.7	9,357	86.1	4,123	82.5	9,141	82.5	1,030	82.5	440	75.0
Foreign	43	10.1	1,503	13.8	869	17.4	1,914	17.3	217	17.4	144	24.6
Unclassified[3]	137	32.2	13	0.1	5	0.1	22	0.2	2	0.1	2	0.4
Total, all corporations	426	100.0	10,873	100.0	4,997	100.0	11,077	100.0	1,249	100.0	586	100.0
Nonmetallic mineral products												
Reporting corporations[2]												
Canadian	683	47.2	1,592	27.1	530	24.6	1,694	36.6	109	29.0	70	27.7
Foreign	96	6.6	3,949	71.8	1,610	74.9	2,837	61.4	265	70.3	178	70.4
Unclassified[3]	668	46.2	61	1.1	10	0.5	92	2.0	3	0.7	5	1.9
Total, all corporations	1,447	100.0	5,602	100.0	2,150	100.0	4,623	100.0	377	100.0	253	100.0
Petroleum and coal products												
Reporting corporations[2]												
Canadian	25	48.1	6,110	30.9	3,299	31.1	3,510	17.0	819	30.5	187	16.6
Foreign	16	30.8	13,676	69.1	7,658	68.9	17,166	83.0	1,867	69.5	944	83.4
Unclassified[3]	11	21.2	1	--	--	--	2	--	--	--	--	--
Total, all corporations	52	100.0	19,787	100.0	10,957	100.0	20,678	100.0	2,686	100.0	1,131	100.0
Total mineral manufacturing industries												
Reporting corporations[2]												
Canadian	954	49.6	17,059	47.0	7,952	43.9	14,445	39.7	1,958	45.4	697	35.4
Foreign	155	8.1	19,128	52.7	10,137	56.0	21,917	60.2	2,349	54.5	1,266	64.3
Unclassified[3]	816	42.4	75	0.2	15	0.1	116	0.3	5	0.1	7	0.4
Total, all corporations	1,925	100.0	36,262	100.0	18,104	100.0	36,378	100.0	4,312	100.0	1,970	100.0

[1] Classification of industries is the same as in Table 28. [2] Corporations reporting under the Corporations and Labour Unions Returns Act. A corporation is considered to be foreign controlled if 50% or more of its voting rights are known to be held outside Canada, and/or by one or more Canadian corporations which are, in turn, foreign controlled. Each corporation is classified according to the percentage of its voting rights which are owned by non-residents, either directly or through other Canadian corporations, and the whole of the corporation is assigned to this particular degree of foreign ownership. [3] Corporations exempt from reporting under the Corporations and Labour Unions Returns Act. These include corporations reporting under other acts, small companies and corporations and non-profit organizations. [4] Included are cash, marketable securities, accounts receivable, inventories, fixed assets, investments in affiliated corporations and other assets. The amounts tabulated are those shown on the balance sheets of corporations after deducting allowances for doubtful accounts, amortization, depletion and depreciation. [5] Equity represents the shareholders' interest in the net assets of the corporation and includes the total amount of all issued and paid-up share capital, earnings retained in the business and other surplus accounts such as contributed and capital surplus. [6] For non-financial corporations, sales are gross revenues from non-financial operations. For financial corporations sales include income from financial as well as non-financial sources. [7] The net earnings from operations, investment income and net capital gains. Profits are tabulated after deducting allowances for amortization, depletion and depreciation, but before income tax provisions or declaration of dividends. [8] Taxable income figures are as reported by corporations prior to assessment by the Department of National Revenue. They include earnings in the reference year after the deduction of applicable losses of other years.

-- Amount too small to be expressed.

TABLE 66. CANADA, FINANCIAL STATISTICS OF CORPORATIONS IN NON-FINANCIAL INDUSTRIES, BY MAJOR INDUSTRY GROUP AND BY CONTROL, 1978 AND 1979

	Agriculture, forestry, fishing and trapping		Mines Quarries & Oil Wells		Manufacturing		Construction		Transportation, communication and other utilities		Trade		Services		Total	
	1978	1979P	1978	1979P	1978	1979P	1978	1979P	1978	1979P	1978	1979P	1978	1979P	1978	1979P
(number)																
Number of corporations																
Canadian control	5,427	6,658	1,643	1,905	13,269	14,711	12,270	13,590	4,696	5,314	34,031	38,414	14,657	16,961	85,991	97,553
Foreign control	104	97	464	441	2,301	2,138	182	176	287	277	2,027	1,859	611	548	5,978	5,536
Other corporations	8,831	9,424	2,175	2,263	16,284	16,852	32,217	35,224	10,983	11,958	64,444	67,932	56,937	63,954	191,871	207,609
Total corporations	14,362	16,179	4,282	4,609	31,854	33,701	44,669	48,990	15,966	17,549	100,502	108,205	72,205	81,463	283,840	310,698
($ million)																
Assets																
Canadian control	3,630	4,795	23,141	27,860	50,802	62,218	13,242	14,517	86,758	98,480	39,679	48,249	16,608	19,364	233,856	275,482
Foreign control	292	288	20,048	27,711	55,675	61,918	1,803	2,013	5,344	5,778	12,222	13,712	4,428	4,050	99,817	115,470
Other corporations	855	895	174	179	1,278	1,335	2,131	2,260	796	866	4,707	4,966	3,442	3,847	13,382	14,349
Total corporations	4,777	5,978	43,363	55,750	107,755	125,471	17,176	18,790	92,898	105,124	56,608	66,927	24,478	27,261	347,055	405,301
Equity																
Canadian control	1,158	1,487	11,818	13,481	20,131	25,014	3,150	3,378	24,570	27,920	11,944	14,255	4,141	4,749	76,911	90,283
Foreign control	116	117	10,543	14,692	27,820	30,514	564	697	1,922	2,158	4,175	4,707	1,591	1,522	46,731	54,406
Other corporations	195	203	-4	-16	265	264	538	507	185	185	1,234	1,188	868	927	3,283	3,259
Total corporations	1,469	1,807	22,357	28,157	48,216	55,792	4,252	4,582	26,677	30,263	17,353	20,150	6,600	7,198	126,925	147,948
Sales																
Canadian control	3,385	4,546	8,208	10,754	63,645	81,490	18,525	20,633	34,010	39,747	102,886	121,017	14,875	17,614	247,527	295,802
Foreign control	245	240	12,048	18,869	85,535	95,669	2,263	2,378	3,109	3,530	30,551	34,842	4,513	4,855	136,272	160,383
Other corporations	835	940	145	158	2,283	2,424	4,126	4,506	1,229	1,333	9,535	10,144	5,130	5,887	23,283	25,391
Total corporations	4,465	5,726	20,401	29,781	151,463	179,583	24,914	27,517	38,348	44,610	142,972	166,003	24,518	28,356	407,082	481,576
Profits																
Canadian control	305	413	2,169	3,642	4,520	6,736	666	814	3,217	4,282	3,870	4,811	1,313	1,556	16,058	22,252
Foreign control	29	29	2,646	5,044	5,494	7,266	185	188	408	502	692	1,082	471	528	9,926	14,639
Other corporations	58	87	4	3	71	62	114	160	49	58	276	357	349	462	921	1,192
Total corporations	392	529	4,819	8,689	10,085	14,064	965	1,162	3,674	4,842	4,838	6,250	2,133	2,546	26,905	38,083

Note: Figures may not add to totals due to rounding.
P Preliminary.

TABLE 67. CANADA, CAPITAL AND REPAIR EXPENDITURES IN MINING[1] AND MINERAL MANUFACTURING INDUSTRIES, 1979-1981

	1979			1980P			1981^{f}		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
					($ million)				
Mining industry									
Metal mines									
Gold	57.0	26.6	83.6	116.2	29.3	145.5	234.9	30.7	265.6
Silver-lead-zinc	87.6	49.0	136.6	166.7	59.3	226.0	196.0	67.1	263.1
Copper-gold-silver	249.6	182.1	431.7	508.1	216.1	724.2	426.5	252.1	678.6
Iron	137.1	295.9	433.0	160.6	280.8	441.4	193.7	285.1	478.8
Other metal mines	356.7	148.7	505.4	499.6	188.2	687.8	721.3	197.3	918.6
Total metal mines	888.0	702.3	1,590.3	1,451.2	773.7	2,224.9	1,772.4	832.3	2,604.7
Nonmetal mines									
Asbestos	98.9	99.4	198.3	95.5	107.2	202.7	110.9	110.9	221.8
Other nonmetal mines[2]	352.5	247.7	600.2	501.3	281.3	782.6	931.4	324.7	1,256.1
Total nonmetal mines	451.4	347.1	798.5	596.8	388.5	985.2	1,042.3	435.6	1,477.8
Mineral fuels									
Oil, crude and gas[3]	4,315.2	686.2	5,001.4	6,157.9	636.9	6,794.8	7,348.8	662.1	8,010.9
Total mining industries	5,654.6	1,735.6	7,390.2	8,205.9	1,799.1	10,005.0	10,163.5	1,930.0	12,093.5
Mineral manufacturing									
Primary metal industries									
Iron and steel mills	370.1	630.6	1,000.7	579.5	742.6	1,322.1	588.6	885.9	1,474.5
Steel pipe and tube mills	77.0	42.2	119.2	59.2	51.4	110.6	138.8	51.8	190.6
Iron foundries	35.9	34.2	70.1	20.2	25.2	45.4	17.6	19.8	37.4
Smelting and refining	238.5	223.2	461.7	504.5	289.7	794.2	540.2	322.7	862.9
Aluminum rolling, casting and extruding	24.5	22.5	47.0	28.8	24.3	53.1	41.1	25.1	66.2
Copper and copper alloy rolling, casting and extruding	5.3	8.5	13.8	18.0	6.8	24.8	24.2	7.5	31.7
Metal rolling, casting and extruding	23.2	14.1	37.3	18.8	14.7	33.5	18.8	14.2	33.0
Total primary metal industries	774.5	975.3	1,749.8	1,220.0	1,154.7	2,383.7	1,369.3	1,327.0	2,696.3
Nonmetallic mineral products									
Cement	127.4	63.1	190.5	129.9	65.1	195.0	91.6	74.3	165.9
Stone products	0.8	0.8	1.6	1.8	1.6	3.4	2.6	1.6	4.2
Concrete products	44.8	29.7	74.5	31.0	33.8	64.8	18.5	33.4	51.9
Ready-mix concrete	30.4	49.8	80.2	40.5	58.1	98.6	33.5	63.6	97.1
Clay products	9.2	6.7	15.9	9.9	7.3	17.2	11.8	8.0	19.8
Glass and glass products	65.6	15.3	80.9	55.0	15.5	70.5	48.6	17.2	65.8
Abrasives	11.5	15.5	27.0	15.8	16.0	31.8	23.4	16.4	39.8
Lime	6.3	5.0	11.3	0.6	6.5	7.1	0.4	6.4	6.8
Other nonmetallic mineral products	99.5	40.4	139.9	67.6	48.4	116.0	65.1	53.9	119.0
Total nonmetallic mineral products	395.5	226.3	621.8	352.1	252.3	604.4	295.5	274.8	570.3
Petroleum and coal products	274.0	219.4	493.4	300.3	256.2	556.5	741.1	296.4	1,037.5
Total mineral manufacturing industries	1,444.0	1,421.0	2,865.0	1,881.4	1,663.2	3,544.6	2,405.9	1,898.2	4,304.1
Total mining and mineral manufacturing industries	7,098.6	3,156.6	10,255.2	10,087.3	3,462.3	13,549.6	12,569.4	3,828.2	16,397.6

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[1] Does not include cement, lime and clay products (domestic clay) manufacturing, smelting and refining. [2] Includes coal mines, gypsum, salt, potash and miscellaneous nonmetal mines and quarrying. [3] The total of capital expenditures shown under "petroleum and gas" is equal to the total capital expenditure under the column entitled "petroleum and natural gas extraction" and under the column "natural gas processing plants" of Table 70.

P Preliminary; f Forecast.

TABLE 68. CANADA, CAPITAL AND REPAIR EXPENDITURES IN THE MINING INDUSTRY[1], 1975–1981

	1975	1976	1977	1978	1979	1980P	1981f
				($ million)			
Metal mines							
Capital							
Construction	499.6	597.6	626.8	407.3	606.4	921.7	1,205.1
Machinery	215.3	305.3	352.0	169.3	281.6	529.5	567.3
Total	714.9	902.9	978.8	576.6	888.0	1,451.2	1,772.4
Repair							
Construction	63.7	61.5	63.1	53.7	70.2	80.3	84.3
Machinery	446.7	521.6	536.7	487.6	632.1	693.4	748.0
Total	510.4	583.1	599.8	541.3	702.3	773.7	832.3
Total capital and repair	1,225.3	1,486.0	1,578.6	1,117.9	1,590.3	2,224.9	2,604.7
Nonmetal mines[2]							
Capital							
Construction	112.8	161.3	214.8	187.5	248.8	305.5	548.2
Machinery	209.6	214.6	225.8	236.4	202.6	291.3	494.1
Total	322.4	375.9	440.6	423.9	451.4	596.8	1,042.3
Repair							
Construction	23.8	20.0	20.8	18.2	14.6	17.9	24.6
Material	184.3	226.2	273.2	289.1	332.5	370.6	411.0
Total	208.1	246.2	294.0	307.3	347.1	388.5	435.6
Total capital and repair	530.5	622.1	734.6	731.2	798.5	985.3	1,477.9
Mineral fuels							
Capital							
Construction	1,355.7	1,598.0	1,998.0	2,520.9	3,820.3	5,475.0	6,439.4
Machinery	219.0	564.1	447.5	382.0	494.9	682.9	909.4
Total	1,574.7	2,162.1	2,445.5	2,902.9	4,315.2	6,157.9	7,348.8
Repair							
Construction	215.2	287.4	318.3	389.6	444.1	351.8	377.5
Machinery	68.5	82.9	101.2	100.2	242.1	285.1	284.6
Total	283.7	370.3	419.5	489.8	686.2	636.9	662.1
Total capital and repair	1,858.4	2,532.4	2,865.0	3,392.7	5,001.4	6,794.8	8,010.9
Total mining							
Capital							
Construction	1,968.1	2,356.9	2,839.6	3,115.7	4,675.5	6,702.2	8,192.7
Machinery	643.9	1,084.0	1,025.3	787.7	979.1	1,503.7	1,970.8
Total	2,612.0	3,440.9	3,864.9	3,903.4	5,654.6	8,205.9	10,163.5
Repair							
Construction	302.7	368.9	402.2	461.5	528.9	450.0	486.4
Machinery	699.5	830.7	911.1	876.9	1,206.7	1,349.1	1,443.6
Total	1,002.2	1,199.6	1,313.3	1,338.4	1,735.6	1,799.1	1,930.0
Total capital and repair	3,614.2	4,640.5	5,178.2	5,241.8	7,390.2	10,005.0	12,093.5

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[1] Does not include cement, lime and clay products (domestic clays) manufacturing, smelting and refining. [2] Includes coal mines, asbestos, gypsum, salt, potash, miscellaneous nonmetals, quarrying and sand pits.

P Preliminary; f Forecast.

TABLE 69. CANADA, CAPITAL AND REPAIR EXPENDITURES IN THE MINERAL MANUFACTURING INDUSTRIES[1], 1975-1981

	1975	1976	1977	1978	1979	1980P	1981f
				($ million)			
Primary metal industries[2]							
Capital							
Construction	200.5	144.8	171.2	130.7	153.4	302.2	317.2
Machinery	614.4	496.1	549.1	475.4	621.1	926.8	1,052.1
Total	814.9	640.9	720.3	606.1	774.5	1,229.0	1,369.3
Repair							
Construction	65.8	63.2	85.3	80.8	87.6	110.5	121.2
Machinery	563.4	632.4	662.8	780.1	887.7	1,044.2	1,205.8
Total	629.2	695.6	748.1	860.9	975.3	1,154.7	1,327.0
Total capital and repair	1,444.1	1,336.5	1,468.4	1,467.0	1,749.8	2,383.7	2,696.3
Nonmetallic mineral products[3]							
Capital							
Construction	41.1	46.6	63.3	62.0	102.0	80.4	51.8
Machinery	158.0	195.4	215.5	217.9	293.5	271.7	243.7
Total	199.1	242.0	278.8	279.9	395.5	352.1	295.5
Repair							
Construction	14.4	15.4	16.1	17.5	20.2	29.0	35.0
Machinery	151.8	164.9	169.5	190.3	206.1	223.3	239.8
Total	166.2	180.3	185.6	207.8	226.3	252.3	274.8
Total capital and repair	365.3	422.3	464.4	487.7	621.8	604.4	507.3
Petroleum and coal products							
Capital							
Construction	337.5	255.9	268.2	215.6	180.0	199.8	540.5
Machinery	112.9	88.3	98.4	99.5	94.0	100.5	200.6
Total	450.4	344.2	366.6	315.1	274.0	300.3	741.1
Repair							
Construction	96.1	101.2	125.7	117.5	158.1	163.2	191.6
Machinery	37.0	35.8	45.8	57.4	61.3	93.0	104.8
Total	133.1	137.0	171.5	174.9	219.4	256.2	296.4
Total capital and repair	583.5	481.2	538.1	490.0	493.4	556.5	1,037.5
Total mineral manufacturing industries							
Construction	579.1	447.3	502.7	408.3	435.4	582.4	909.5
Machinery	885.3	779.8	863.0	792.8	1,008.6	1,299.0	1,496.4
Total	1,464.4	1,227.1	1,365.7	1,201.1	1,444.0	1,881.4	2,405.9
Repair							
Construction	176.3	179.8	227.1	215.8	256.9	302.7	347.8
Machinery	752.2	833.1	878.1	1,027.8	1,155.1	1,360.5	1,550.4
Total	928.5	1,012.9	1,105.2	1,243.6	1,412.0	1,663.2	1,898.2
Total capital and repair	2,392.9	2,240.0	2,470.9	2,444.7	2,865.0	3,544.6	4,304.1

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[1] Industry groups are the same as in Table 28. [2] Includes smelting and refining. [3] Includes cement, lime and clay products manufacturing.
P Preliminary; f Forecast.

TABLE 70. CANADA, CAPITAL EXPENDITURES IN THE PETROLEUM, NATURAL GAS AND ALLIED INDUSTRIES[1], 1975-1981

	Petroleum and natural gas extraction[2]	Transportation including rail, water and pipelines	Marketing (chiefly outlets of oil companies)	Natural gas distribution	Petroleum and coal products industries	Natural gas processing plants	Total capital expenditures
				($ million)			
1975	1,427.2	361.9	152.8	192.7	450.4	147.5	2,732.5
1976	1,998.8	337.3	164.9	182.3	344.2	163.3	3,190.8
1977	2,290.0	374.9	135.5	213.0	366.6	155.5	3,535.5
1978	2,684.1	312.4	145.6	246.6	315.1	218.8	3,922.6
1979	4,013.4	229.3	134.3	262.5	274.0	301.8	5,215.3
1980P	5,827.2	589.3	206.4	371.7	300.3	330.7	7,625.9
1981f	6,734.2	1 605.6	288.3	498.9	741.1	614.6	10,482.7

[1] The petroleum and natural gas industries in this table include all companies engaged in whole or in part in oil and gas activities. [2] Does not include expenditures for geological and geophysical operations. See also Footnote 3 to Table 67.

P Preliminary; f Forecast.

A

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